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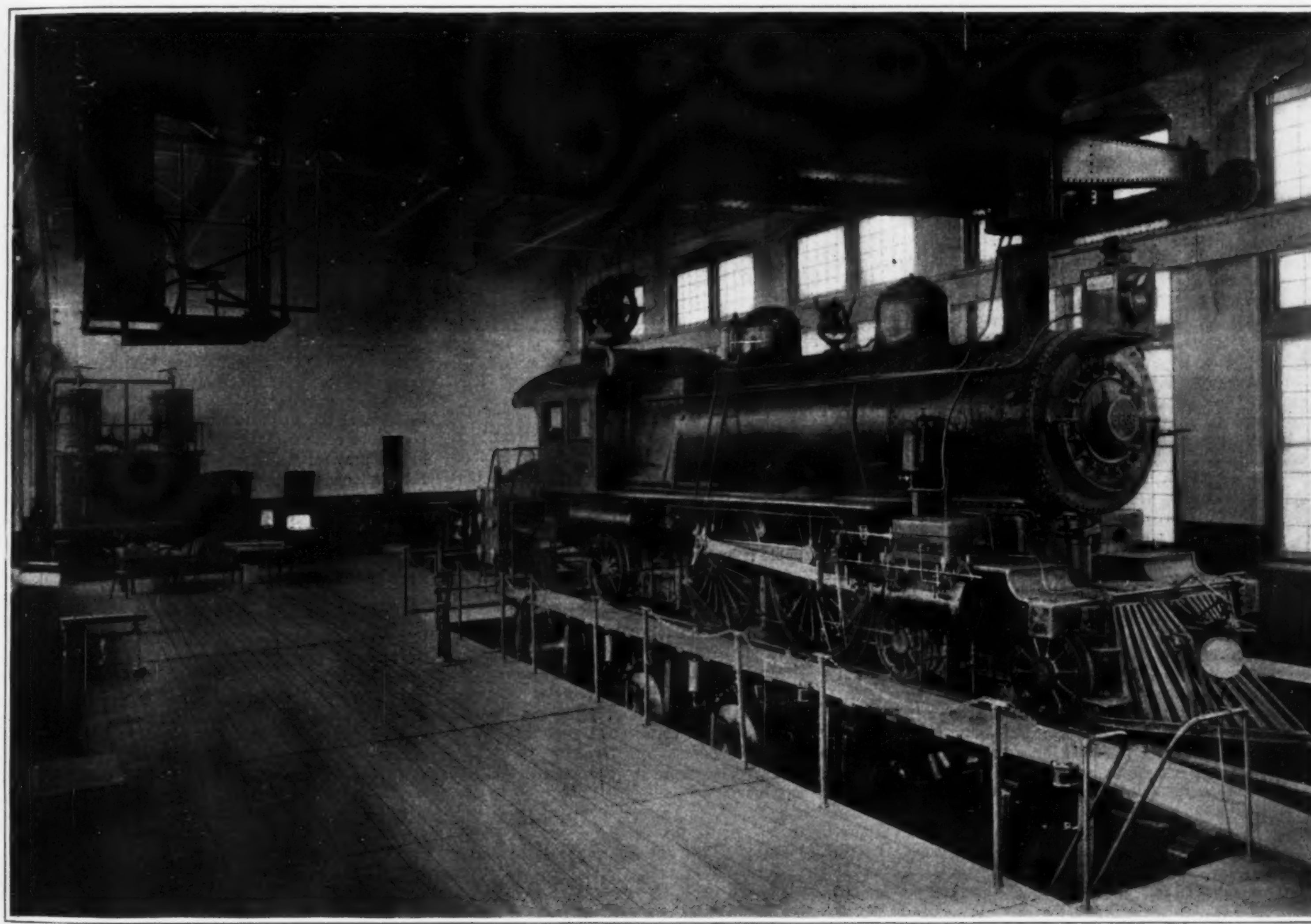
Testing Materials of Construction.

How the Pennsylvania Railroad Guards Against Loss By Poor Materials.

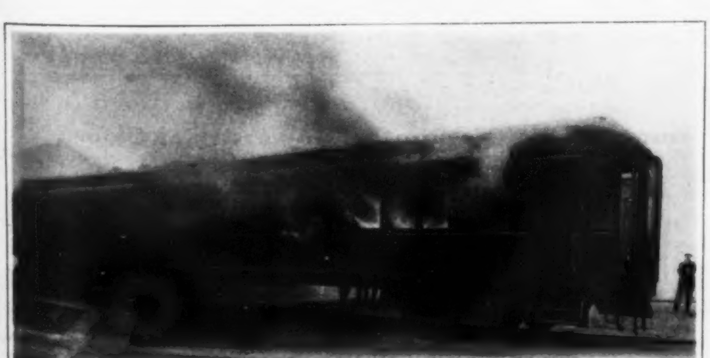
While wide publicity is being given to statistics showing, or purporting to show, how the railroads waste millions very year through unscientific methods, some railroads are endeavoring to show what they are doing to promote economy.

The Pennsylvania Railroad has departments for the sole purpose of insuring it against loss through the use of poor materials. These departments do not bring in a dollar of direct revenue, but every year they save the company hundreds of thousands of dollars above the cost of their maintenance. Over two hundred men are employed in these departments, and among them are some of the most skillful engineers and chemists in the country. The departments are known as the test department and the chemical laboratory. The first is in charge of the engineer of tests and the second is operated under the direction of the chemist of the Pennsylvania Railroad. Both are situated at Altoona, Pa.

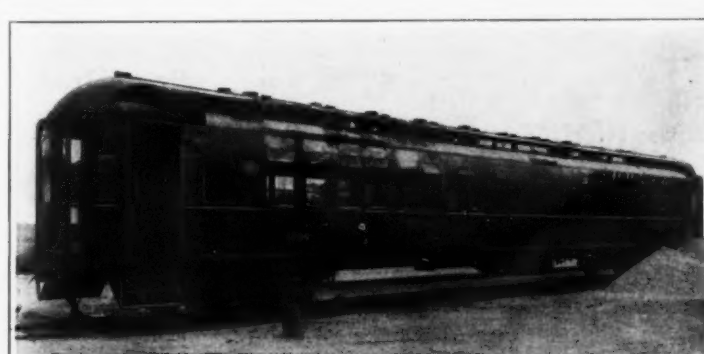
The following illustration will serve as an instance of the saving possibilities of this department. A short time ago the engineers in charge of the locomotive testing plant noticed that a certain coal was not producing the right amount of steam per pound. Upon investiga-



The Locomotive Testing-room.



Several Tanks of Oil and 150 Pounds of Kindling Wood Were Placed in One End of the Car.



Note That the Fire Has Not Spread to the Further End of the Car.

FIRE TEST OF A STEEL PASSENGER COACH

tion it was found that the coal was coming from an outcrop, a vein lying outside the ground, where it was damaged by exposure to the weather. Shipments from this source were immediately stopped when the attention of the company furnishing the coal was directed to the matter. On the road it would probably not have been noticed, and it is estimated that the discovery saved enough to pay a month's expense of operating the testing plant.

Some unique tests recently conducted were those made in an effort to find a fireproof headlining for passenger cars. The headlining is the thin layer of material with which the ceiling is finished. A steel coach was filled with boards and shavings saturated with oil. Two large cans of oil were placed on scantlings run between the window sills. When this was ignited there was little doubt that anything which withstood the ensuing blaze was fireproof.

The longest and heaviest train ever operated was run from Altoona to Enola, Pa., a distance of 127 miles, under the direction of this department. The length of the train was 4,888 feet—more than nine-tenths of a mile—and the engine was connected with the caboose by telephone. It consisted of 120 steel gondola cars loaded with 6,450 tons of coal, and was pulled at the rate of 13 miles an hour by a single locomotive of the type technically known as the "H-8-b." Including equipment the load was 16,888,000 pounds.

While it was announced that it was not the intention of the Pennsylvania Railroad to operate such heavy trains in regular service, the company stated that the tests were made to determine the capacity of its freight locomotive over the improved lines where grades have been removed and curves compensated. Such trips have been made frequently, but the latest one represents the heaviest movement ever secured.

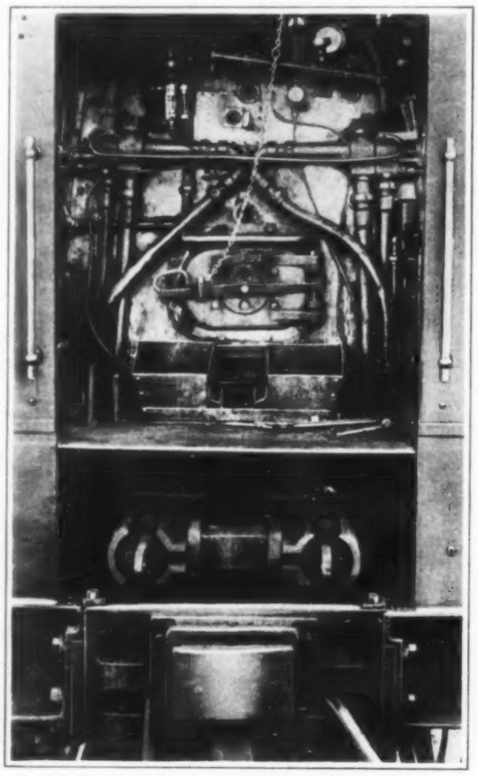
Scientific management carried to the highest degree is practiced by the Pennsylvania Railroad in the purchase of supplies, and by supplies is meant everything from a rubber band to steam locomotives. Inspectors are stationed so as to be available at every manufactory from which materials or equipment are bought. Not only are the finished products subjected to a rigid examination before they are accepted, but the material which is bought by outside companies must pass the scrutiny of these inspectors if it is destined for equipment ordered by the Pennsylvania. Something of the importance of the work is indicated by the enormous amounts inspected by these men each year. A few of the things they passed on in 1910 are: 33,734,552 pounds of steel castings, of which 32,573,173 pounds were accepted and 1,161,379 pounds were rejected; 211,453 wheels, of which 208,934 were accepted, and 2,519 were rejected; and 16,978 yards of plush, all of which was accepted.

These outside inspectors are under the direction of three resident inspectors with headquarters at Altoona, Pittsburgh, and Philadelphia. Some things, such as car couplers, axles, etc., they test themselves at the works where they are made. Usually, however, specimens are sent to the laboratories at Altoona, where they are put through physical and chemical tests, the results of which are compared with the specifications.

The company relies on its experts to protect it and will accept nothing that does not come up to the specifications prepared by them. These cover practically everything that is used by a railroad. The wide range of articles they embrace is shown by a glance down the list, from automatic couplers, tin, and lumber for ties and telegraph poles, to caustic soda, Tuscan red, soap, passenger car thermometers, and sponges. Every year new specifications are added and the old ones are constantly being revised to conform with more complete knowledge or more stringent requirements.

The thoroughness and independence of this branch of the work is illustrated by some special experiments that are now being made in the chemical laboratories. At present there are no chemical specifications for rubber, except those prepared by the government. Instead of accepting these, as others have done, the Pennsylvania's experts are making an exhaustive study of the subject in order to have specifications that they know are adequate.

Some of the routine tests made in the chemical laboratory are those on water, metals, cement, etc. Careful watch must be kept on the water used by locomotives to see that it does not contain substances that will form scale on the inside of the boilers. In localities where good water cannot be obtained soda ash is put in to prevent harmful effects.



A Crawford Mechanical Stoker Going Through a Test-trial.

Little trouble is experienced with the manufacturers of cement over refusals to accept their product, because the tests are open to them and they can always be shown the reasons for non-acceptance.

Thirty-five thousand eight hundred and seventy-two samples of various materials were examined in the chemical laboratories in 1910, and 121,970 determinations made. Among the special subjects investigated were drinking water, disinfectant, paint and varnish removers, steel wheels, rails, etc., with studies on smoke-preventing devices.

In the physical laboratories is a room where electric lights used in cars are tested. The life of a lamp that is supposed to last 1,000 hours is tested in about four hours by increasing the load fifty per cent. There is another apparatus to test the endurance of the lamps under vibration, such as they would be subjected to on a moving train.

In the laboratory for testing iron and steel are powerful testing machines for determining the elastic limit, the point where the steel begins to stretch; the ultimate strength or breaking point; and the elongation between the elastic limit and the breaking point.

The physical laboratories tested 97,759,972 pounds of bar iron last year, accepting 93,752,923 pounds, and rejecting 4,007,049 pounds; 840,750 pieces of air brake hose, accepting 732,450 and rejecting 108,300 pieces; 3,000,480 pounds of cotton waste, accepting 1,992,205 pounds, and rejecting 1,008,275 pounds, but these are only a few items picked out at random. Fifty-eight thousand one hundred and ninety-three routine tests were made during the year.

Theoretically every bolt and rivet, every piece of wood or steel that goes out on the Pennsylvania Railroad is competent to do the work allotted to it, with a store of reserve strength for any extraordinary strain.

If the theory on which the test department works could be carried out perfectly in practice there would be no breakage. But, naturally, this is impossible where the work is done by men who are bound to make mistakes sometimes. Broken parts are always sent to the laboratories, and a large part of the business consists of investigating the causes of such breakage in order to prevent repetition. Almost incalculable loss is avoided in this way. If the break is due to a miscalculation the department can lay its finger on every other piece of equipment that could have been affected before more damage is done. Or, if it is due simply to wear from age, it offers a clue for the investigation of similar parts that were put in use at the same time.

The most unique feature of the test work at Altoona is the locomotive testing plant. By the arrangement of the apparatus here installed the largest engines can be run at top speed without traveling an inch, so that constant results are obtainable and measurements can be made and tabulated with far greater exactness than is possible in road trials. The amount of fuel consumed, the water evaporated, the weight of the sparks and cinders, part of which are lost up the smokestack, the friction of the various parts—these are only a few of the elements of locomotive performance that are ascertained.

A locomotive undergoing a test rests on supporting wheels. The drawbar is attached to a stationary dynamometer with scales that weigh the pull. The supporting wheel axles extend so as to receive absorption brakes and the work done consists in overcoming the resistance of the wheels and brakes, the force exerted by the drawbar being measured by the dynamometer. Pens attached to the scale levers make a permanent record of the performance in diagram form.

Since the plant was installed in 1906, 1,539 tests have been made. Inventions are given a trial and men are constantly at work perfecting the locomotive. At present an automatic stoker is being tried out. Of course road tests are also conducted by the department, and men trained in the plant are sent out along the lines as inspectors to show how to profit by what is learned.

The Pennsylvania Railroad began the testing of materials in 1875. The establishment of the laboratory took place in 1879, with a force of only four men, two on chemical and two on physical tests. From that time the history of the department has been one of rapid growth both in size and importance, until to-day it is one of the vital parts of the great railroad system. It is a sort of bureau of scientific management where problems arising daily are studied out, and where infinite time and pains are expended in working toward the perfection that means the least waste and the highest efficiency.

The Great Star Map—VI*

Some Incidents of the Work

By H. H. Turner, DSc., D. C. L., F. R. S., Savilian Professor of Astronomy in the University of Oxford

Continued from Supplement No. 1865, page 211.

The general history of this enterprise as exemplified more particularly in the portion of the work undertaken at Oxford has now been given and it remains to notice several incidental investigations of different kinds which have branched from the main project. In a piece of work already extending over about twenty years, in a new department of science such as the application of photography to astronomy, it is only natural that the consequences of the departure should not have been foreseen in their entirety at the outset.

The first novelty which attracted our attention at Oxford was what is called the "magnitude equation" of the Cambridge meridian observations. In order to determine completely the places of the stars on any one of our photographic plates, it was necessary to know the places of a few of them in the sky, so that we might virtually peg down the plate in its proper place on the sky and refer all the new and previously unmeasured stars to their proper positions. For this purpose a large number of meridian observations made at the Cambridge Observatory some years before were ready to hand. Having selected the stars required and used them without difficulty for the purpose described, we found what are called the "constants of the plates." For each plate two stars would have sufficed, had everything been theoretically perfect.

But in order to compensate for the small errors of various kinds unavoidable in scientific work, it was desirable to make use of many more stars than the theoretical minimum. From the general average of all the stars considered we ascertained the relative errors of individual stars; it was soon seen that a peculiarity was manifest in the individual errors depending upon the brightness of the star, and from

* Reprint from *Science Progress*

independent information it was known what was the reason of the discrepancy.

The Cambridge observations had been made by watching the transit of a star across spider webs, recording the time of transit according to the clock. It has long been known that different observers have a persistent personal characteristic which has been called their "personal equation," in virtue of which they are systematically a little early or a little late in their records. More recently it has been found that even the same observer will vary in his habit according to the brightness of the star, the general tendency being to be late for the faint stars. The tendency is more marked in some individuals than others. The Cambridge observer (the late Mr. A. Graham) apparently had a strongly marked tendency of this kind.

Various methods have been suggested for the valuation of this habit, especially the method which depends on using gauze screens to reduce the light of a star and thus to substitute for it a virtually fainter star occupying exactly the same space as the brighter one. If the observer were free from the magnitude equation error, he would make a record of the transit precisely the same in the two cases; but if he be subject to the malady, his records will differ by an amount which affords a measure of his predisposition. There are, however, some difficulties of a practical kind in using this method, and it was pleasant to realize that in the photographic plate we had found a simple and effective means of determining the magnitude equation without the necessity for any special observations on the part of the observer.

A few details may be given which bring out some interesting points. The first attempt at detecting the magnitude equation from the Oxford measures was made by Mr. Hinks in 1897, when only seven plates had been measured (*Mon. Not. R.A.S.* lvii. p. 473). The material available was only sufficient to demonstrate the value of the method. Mr. Hinks recording his opinion that "when the reductions for the Astrographic Catalogue are completed, it will be possible to discuss very accurately the personal equations depending on magnitude." The reductions are now completed and the discussion is being undertaken; but we did not wait until now for confirmation of the forecast. In 1899, when 600 plates had been measured, an examination was made of the accumulated measures (*Mon. Not.* lx. p. 3), the stars being grouped in half-magnitudes; and it was found that the fainter stars had been "observed late" by Mr. Graham as follows, taking as standard those of magnitude 6.0:

DETERMINATION OF MR. GRAHAM'S MAGNITUDE EQUATION IN 1899.

		s.	
Magnitudes 6.5 to 6.9,	147 stars,	0.016	late.
Magnitudes 7.0 to 7.4,	320 stars,	0.025	late.
Magnitudes 7.5 to 7.9,	504 stars,	0.038	late.
Magnitudes 8.0 to 8.4,	572 stars,	0.059	late.
Magnitudes 8.5 to 8.9,	1,226 stars,	0.086	late.
Magnitudes 9.0 to 9.4,	2,001 stars,	0.146	late.

It will be noticed that there are roughly twice as many stars in the second group as in the first, and in the third twice as many again, this being the natural increase of stars in the sky as we go to fainter magnitudes. But at the fourth group there is a discontinuity, owing to the fact that only half the available material was discussed beyond this point. The labor was considerable and it was thought that the examination, which was in any case only preliminary, need not be carried further at that time. In the fifth and sixth groups the increase is resumed. The discontinuity should not, of course, affect the averages in the last column, and we see that there is an increase of "lateness" which seems to be rapidly growing, since not only the quantities themselves, but their differences, get larger and larger. There is no suggestion of a sudden jump, such as we shall notice in a moment: the smoothness of the growth was considered to be satisfactorily established and the matter was left there until the present time. The measures are now printed and a final examination can be made, using the whole material and classifying the stars in smaller subdivisions, especially where they are numerous, as is the case for the fainter magnitudes. The work is only in its early stages but already an important new fact has come to light, as will be seen from the following figures, from which the brighter stars have been omitted, because hitherto only a few observations of them have been collected definitely:

PROVISIONAL RESULTS FROM THE EXAMINATION OF 1911.

		s.	
Magnitudes 7.9, 8.0 and 8.1,	84 stars,	0.049	late.
Magnitudes 8.2, 8.3 and 8.4,	102 stars,	0.052	late.
Magnitudes 8.5, 8.6 and 8.7,	197 stars,	0.073	late.
Magnitudes 8.8 and 8.9,	143 stars,	0.085	late.
Magnitudes 9.0,	259 stars,	0.098	late.
Magnitudes 9.1,	138 stars,	0.155	late.
Magnitudes 9.2,	124 stars,	0.170	late.
Magnitudes 9.3,	130 stars,	0.176	late.
Magnitudes 9.4,	81 stars,	0.178	late.
Magnitudes 9.5,	154 stars,	0.191	late.

The remarkable thing here is the sudden jump from magnitude 9.0 to 9.1, after which the further change is small. The actual difference in brightness of the star is so small that it is hard to believe that this discontinuity can have arisen naturally. It is possible that the observer had some special rule of procedure when he set out to observe a star catalogued as fainter than ninth magnitude—for instance, he may have arranged the illumination differently. The further investigation of this matter must be left until more stars have been examined; but enough has been said probably to show the value of the photographic measures as a check on intricacies of personal equation.

A new enterprise of a more important and unforeseen kind arose from the discovery of the little planet Eros in 1898. Our solar system, which at the time when the days of the week were named contained only five planets in addition to the sun and moon, is now known to consist of many hundreds, and new members are being discovered almost weekly. Most of them are tiny rocks, probably not more than one or two hundred miles across, with no perceptible influence on the movement of their more important brothers and sisters; in fact, of no particular interest, as far as we can see at present. Astronomers were beginning to get rather tired of the continual discoveries of new small planets, which brought increased responsibility for keeping watch on them and increased labor in calculating their movements, without any obvious advantage from the increase in our knowledge.

It was therefore a distinctly sensational incident when one of these discoveries proved to have a considerable importance, owing to the fact that the tiny object moved in an orbit which, in one part, was exceedingly close to the orbit of the earth. The orbits of these small planets lie in general between those of Mars and Jupiter, and up to 1898 none of them had been suspected of approaching the earth nearer than the planet Mars. But it was seen that the orbit of Eros lay within that of Mars, and that only a few years previous to its discovery (namely, in 1894) the earth and Eros had been simultaneously in the adjacent portions of their orbits and had therefore been very close together.

Now such a close approach affords an opportunity of a special kind for determining accurately the distance of the little planet from the earth. Usually the planets are so far away that their distances are many hundreds of million miles, exceeding the diameter of our tiny earth so vastly that it is difficult to institute an exact comparison between the two, as we must if we wish to express the former in units familiar to us. The difficulty is precisely the same as that which we find in realizing the distances of remote objects by the use of our eyes alone. There is no similar difficulty in perceiving the distances of objects close to us—say those within an ordinary room: they present different aspects to our two eyes and from these differences in aspect we are able to judge of the distances. But the change of aspect is smaller for objects more remote and we know that it is entirely insensible for an object so remote as the moon. Indeed, our power of perceiving distance by means of the difference in aspect for our two eyes breaks down long before we reach the moon, although we do not always realize the breakdown, because other methods based on general experience frequently come to our aid.

In the same way, astronomers pointing telescopes from opposite sides of the earth to the same object can perceive its distance by a method similar to that we use unconsciously when we look at anything with our two eyes. But the observations become difficult when the object is too far away and are only satisfactory for a comparatively close object.

The heavenly body closest to ourselves is of course the moon; and we know its distance within twenty miles. Up till 1898 the next closest known were Mars and Venus, on favorable occasions; and accordingly much time and trouble have been spent in determining the distances of these two planets when there has been a Transit of Venus or a favorable Opposition of Mars.

(To be continued.)

Why the Earth Appears Concave

An Optical Illusion Observed From Balloons

By Dr. Charles Forbes, Columbia University

Balloonists and aviators tell us that the surface of the earth appears concave or bowl shaped to them while high up in the atmosphere. The question is often asked why this should be the case. The illusion is due to a purely physical cause, namely, atmospheric refraction. A simple experiment in the refraction of light will aid in understanding the explanation to follow. The experiment may be performed as follows. Select a dish, shaped somewhat like the one illustrated in Fig. 1. Place a bright object, say a 50-cent piece, in the center of the dish. Then stand

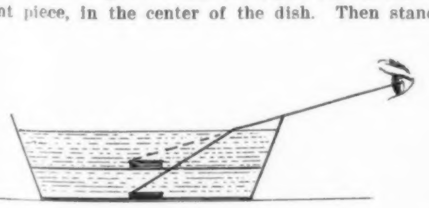


Fig. 1. Effect of Refraction at a Plane Surface in Altering the Apparent Position of an Object.

in such a way that when looking over the edge of the empty dish the more distant edge of the bright object will be just out of view. While in this position have an assistant pour water into the dish, nearly filling it. The bottom of the dish will appear to be elevated, bringing the bright object into view as represented, in the illustration, by the dotted line. The experiment may be varied as follows. First, look directly downward on the bright object; on pouring water into the dish the object will have no apparent displacement. Next repeat the experiment, as originally described, a number of times. Each time place the coin so that it will be seen in a more slanting direction with each successive repetition. The experiments thus performed reveal the fact that the more slantingly the object is seen the greater will be the displacement. The general law of refraction is thereby illustrated, namely, that when light passes in a slanting direction from a dense into a rare medium, as from water into air, the light is bent away from a perpendicular to the surface of the denser medium; the more slanting the direction the greater the refraction. The law is scientifically stated as follows: Whatever the obliquity of the incident ray, the ratio which the sine of the incident angle bears to the sine of the angle of refraction is constant.

The apparent displacement of the object in the experiment described is due to the fact that must be kept constantly in mind, namely, an object is always seen in the direction in which the light enters the eye. Referring to Fig. 1, the ray of light issuing from the object in the bottom of the dish is refracted at the surface of the water and thence enters the eye as indicated by the straight line. On tracing this straight line backwards from the eye as indicated by the dotted line the object will appear to be elevated.

Thus far in the explanation, two media have been considered, water and air. In the case of a single medium, homogeneous in density, light undergoes no refractive change in direction. When, however, the medium is not uniform in density, oblique rays are

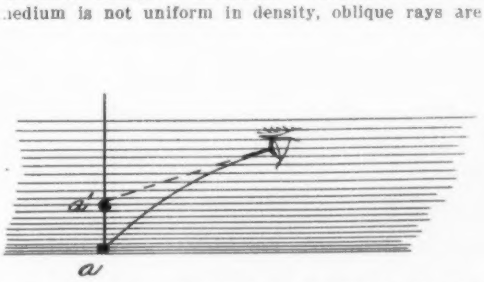


Fig. 2. Effect of Refraction in Medium of Varying Density Altering the Apparent Position of an Object.

refracted. Fig. 2 is illustrative in the medium of the air, the upward decreasing density of which is represented by the decreased intensity in the shading. A ray of light issuing from the object at *a*, and passing vertically upward undergoes no refractive change.

The oblique ray issuing from the same point a, undergoes a refractive change represented by the curved line. It enters the eye as if it came in a straight line from the point a'; for the reason heretofore stated, that an object is seen in the direction in which the light enters the eye, and the object appears elevated.

Returning now to the case of the balloonist and the concave appearance of the earth's surface. Fig. 3 illustrates the subject. The curved line 4-3-2-1-2-3-4 represents the convex surface of the earth above which the air is supposed to extend with decreasing density. The eye of the balloonist is represented at O. A ray of light passing from 1 upward to the eye at O passes in a straight line. From 2 the light passes in a slanting direction and it is refracted in a curved line. Tracing this ray backward from the direction it has on entering the eye it appears to have started from 2'. In like manner the ray from 3 appears to have started from point 3'. In turn the ray from point 4 enters the eye at O as if it came from 4'. The rays from the points 2, 3 and 4 pass successively in more and more slanting directions, thereby resulting in increased atmospheric refraction. If the points 4'-3'-2'-1-2'-3'-4' be connected by a dotted line we have represented the concave appearance of the earth's surface to the eye as seen from the balloon or aeroplane. The concave or bowl shaped appearance is therefore a physical phenomena due to atmospheric refraction.

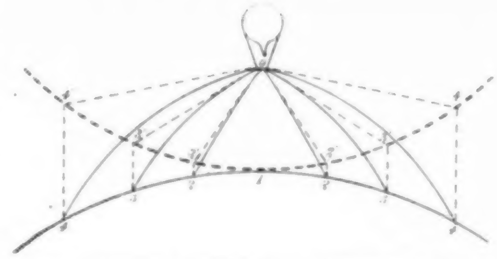


Fig. 3. Diagram Showing How Atmospheric Refraction Makes the Earth Appear Bowl-Shaped as Seen from a Balloon.

New Apparatus for Sewage Purification

Mechanical Aids to the Treatment of Drain Effluents

By the Berlin Correspondent of the Scientific American

UNTIL about ten years ago, the general practice in Germany, after the example of England, had been to authorize the discharge of municipal sewage containing fæcal matter into the course of rivers, only after a thorough purification by irrigation over a suitable area of land.

This attitude has, however, undergone some modification of late, and the leading German authorities now consider a purely mechanical purification (by means of rakes, grates, screens, settling tanks, etc.) quite sufficient even in the case of considerable amounts of sewage, provided the conditions of flow be favorable. In fact, the power of self-purification possessed by rivers was found to be considerably greater than had been supposed, provided that the sewage is introduced in a condition as fresh as possible. Experience has long shown that the fish inhabiting the river preferably haunt those places where fresh sewage water containing plentiful food comes in.

Apart from the great variety in the composition of sewage, its extraordinary power of adhesion makes a mechanical treatment especially difficult. In fact, these forces of adhesion are so considerable that particles cling tenaciously to all walls and angles, adhering even to quite smooth and vertical surfaces and forming a viscous gelatinous layer that can be removed only by a very thorough purification.

A novel type of mechanical purifier which, while thoroughly effective, is incomparably cheaper in cost of installation and operation than the expensive system of sewage farming, has been installed in some German cities, by Wilhelm Wurl, of Berlin-Weissensee, on the Riensch patents. These purifiers are huge rotating disks made up of a number of brass or bronze plate segments into which are milled or punched slots 1 to 5 millimeters in width widened conically toward the bottom. This design furnishes a smooth and level surface without any projections to which the mud may cling, while presenting an excellent contact surface for the purification of the sewage.

The frame carrying these sieve segments is built in a slanting position, into the water to be sifted. After arriving at the rotating disk, the water traverses the sieve segments, passing through the discharge channel directly to the river or else to a final purifier.

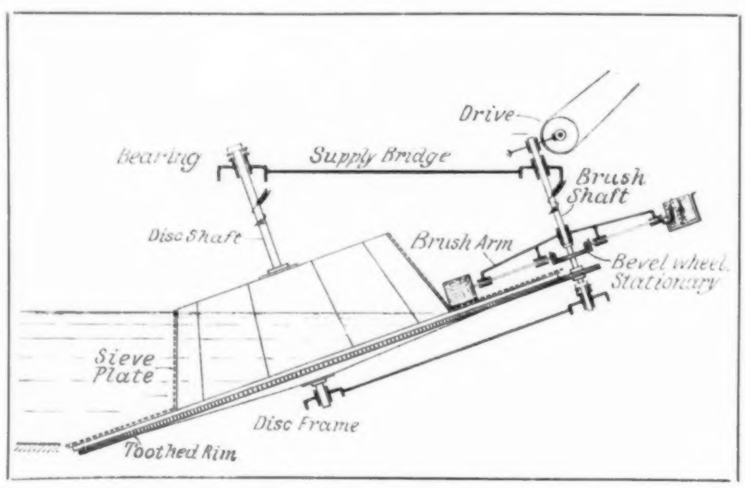
The scraper, consisting of a star of levers carrying rotating brushes, is mounted on a second shaft parallel to that of the disk. After being slowly lifted by the rotating disk, the mud particles separated from the water are removed by these brushes working over the upper part of the disk, above the level of the water, and are thence converged through a chute to suitable mechanical transporting devices. The drive is effected either by a transmission shaft or by a direct-coupled motor, the brush-lever shaft itself rotating the disk through a suitable gearing.

The brushes are attached to the levers by joints insuring a uniform application. So far from being pressed against the sieve segments, they thus slide lightly over their surface, while continually rotating round their axes. Proper weights and counterweights allow the pressure of application to be adjusted at will.

In order with each rotation to free the brushes of the particles clinging to them, they are made, after being lifted off the sieve disk, to travel over a cleansing rake from which they are finally again lifted automatically, and reapplied to the sieve disk. The cleansing rake, after removing any solid particles clinging to the brushes, drops them into a trough placed underneath. The conical sleeve fitted upon the center of the disk is likewise cleaned by one or more rotating brushes which are so arranged as to drop any mud on the outer (level) part of the disk, whence the brushes above described will remove it.

A special advantage of this apparatus is that the purification process occurs outside of the water. The nature of process and the continual repetition of the brush-action insure the strictest cleanliness of the sieve segments. This allows extremely narrow sifting slots (down to one-half millimeter) to be readily used. Again, the circular profile of the disk perfectly adapts itself to the cross-section of conduits and affords the advantage that the area allowed for the passage of water increases in proportion to the speed of flow.

A New Mechanical Sewage Purifier.



Sectional View of the New Sewage Purifier.

The Use of Tar on Roads

Some Objections Reported

AN experimental application of tar to roads was made in Monaco about ten years ago. Similar experiments have since been made in many lands and their results have been discussed by the International Road Congresses which met at Paris in 1908 and at Brussels in 1910. The Brussels Congress concluded that the superficial application of tar to roads had definitely entered into practice. It is certain that the dust nuisance is very greatly abated by tarring. The economic advantages of the practice, together with certain objections that have been urged against it, are discussed by Dr. Guglielminetti, the founder of the French Anti-dust League, in an article in *Le Génie Civil*, which is here summarized.

All roadmakers agree that the application of tar diminishes the wear of the road, prolongs its life and considerably lessens the cost of cleaning, including sprinkling, scraping and sweeping. It has hitherto been difficult to form a quantitative estimate of the saving thus effected, because, in most cases, the weather and the character and volume of traffic vary so greatly from year to year that a rather long period must be considered in order to obtain a fair average result.

The calculation is comparatively easy in the case of the Avenue du Bois de Boulogne, in Paris, on which heavy traffic is prohibited. This fine avenue, about one mile long and 52 feet wide, descends by a very gentle grade from the Place de l'Etoile to the Porte Dauphine entrance to the Bois de Boulogne. The total area of the macadamized driveway is about 28,300 square yards. The driveway was freshly macadamized in September, 1906, and was tarred for the first time in May, 1907, and again in April, 1908. Since that time it has been tarred twice annually, in April and September, and has not been relaid.

although it was formerly relaid every third year. It was relaid in March, 1903, at a cost of $22,500, and the cost of maintanance and repairs between that date and September, 1906, was $12,000, making a total cost of $34,500 for a period of 3½ years, in which no tar was applied. This is equivalent to 35 cents per square yard per year. In the succeeding period of 4½ years ending in March, 1911, the charges were $19,500 for relaying in September, 1906, $6,250 for maintenance and repairs, and $6,400 for seven applications of tar, making a total cost of $32,200, and an average cost of 25 cents per square yard per year.

The comparison of these two periods, therefore, shows a saving of more than one-fourth of the cost of relaying, maintenance and repairs, in addition to the diminution of the cost of cleaning. The single coating of tar applied in the spring of 1907 barely lasted through the ensuing winter but since the application has been repeated in the autumn the roadway has been found in excellent condition in the spring.

For this avenue the economic advantage of tarring is thus demonstrated. The life of the macadam is certainly doubled and the interruption of traffic by relaying, an operation which occupies nearly two months, is made correspondingly less frequent. The interruption of traffic caused by tarring lasts only a few days.

In regard to the suppression of dust the result is marvelous. The avenue was formerly very dusty on hot sunny days although it was sprinkled at intervals of two or three hours. A daily sprinkling now suffices and nobody complains of the dust. The avenue is traversed daily by 40,000 automobiles, so that frequent sprinkling is almost impossible and on race days pedestrians used to be greatly annoyed by the clouds of dust raised by vehicles returning from the races.

In short, it was impossible to keep in good condition an avenue which now excites the admiration of road engineers of all nationalities.

On this avenue, however, the traffic is light, though active, and it would be rash to assume that equally good results would follow the application of tar to all macadam roads. The character of the road and of its traffic is evidently an important economic factor and it is necessary to know, not only how and when to apply tar, but also to what roads it can be applied with success. The neglect of this principle may explain the disagreement between urban and rural roadmakers at the Brussels Congress. The former, recognizing the inevitable tendency of city traffic to become heavier as well as more congested, recommended the gradual substitution of stone, wood or asphalt pavement for macadam in cities, while the rural engineers insisted that macadam, tarred at proper intervals, would be perfectly satisfactory for city streets having comparatively light traffic.

Many apparent failures of the tarring process are clearly attributable to an injudicious selection of roads. It would be absurd to tar a macadam road which must be relaid every year or two, owing to the nature and volume of the traffic. Such a road should be paved, and the use of tar should be restricted to roads which, if macadamized and properly tarred, will not need renewal oftener than once every three years.

It has been asserted that inflammation of the eyes is caused by the tarry dust which rises from tarred roads and that vegetation is injured by this dust and by the vapor of tar. The first charge has not been proved. No serious complaint of this nature has been made in regard to the Avenue du Bois de Boulogne or the road from Paris to Versailles, which is tarred throughout its whole length. The writer, who drives or walks daily on the avenue, on which his house is situated, has never heard the slightest objection on this score. The streets of Cannes, Nice and Menton, and the highway which connects those cities have been tarred annually for the past eight or nine years without provoking any complaint of injury to the eyes.

Conjunctivitis has been produced in rabbits and guinea pigs by rubbing their eyes with tarry dust. This is not surprising, for tar is not a remedy for sore eyes and conjunctivitis can be produced by rubbing the eyes with ordinary dust. These laboratory experiments have no practical bearings, as the experimenters admit.

In regard to the injurious influence of tarred roads on vegetation the application of tar is defended by road engineers and the cause of the plants is sustained by horticulturists, but the two parties are not as directly opposed as they appear at first sight. In fact, the curator of the Bois de Boulogne, despite his fears for his plants, admits the necessity of tarring the principal roads of the Bois in order to make the adjacent walks practicable in this era of the automobile.

M. Griffon, in a communication to the Academy of Sciences, makes a distinction between the effects of tarry vapors and tarry dust on plants. Vegetable cells are killed by hot vapor of tar but in practice the thin layer of tar applied to roads quickly cools and the vapor is diluted by an immense volume of air. M. Griffon has not detected any direct effect on plants produced by the vapors evolved in the operation of tarring roads, in Paris. The tarry dust burns the delicate leaves of begonias, pelargoniums and saxifrages on which it settles, but no injurious effect was noted in the case of many other plants, shrubs and trees.

In England, where 2,000 miles of road were tarred in 1908 and 10,000 in 1910 no serious complaint of injury to plants or eyes was elicited by an inquiry instituted by a technical journal, *The Surveyor*. A similar negative result followed an inquiry made in Germany by *Der Strassenbau*. No complaint has arisen in Belgium, where the practice of tarring roads is well established. In the south of France where the funds raised by the Anti-Dust League for tarring the State roads are doubled by the State and $10,000 are annually expended for this purpose, the owners of villas adjacent to these roads are the largest contributors to the fund, and no complaint of injury has been made.

The injurious effects observed in certain plants in Paris appears, therefore, to be attributable to a peculiar weakness of these plants in that climate and environment, and the obvious remedy is the selection of more resistant species for planting along tarred roads which are at once much traveled and greatly exposed to sun and wind—a combination, in respect to which few roads can be compared with the avenue and roads of the Bois de Boulogne. In order to decide the question the Prefect of the Seine has appointed a commission which will make comparative tests between similar plants growing beside tarred roads and roads not tarred in similar conditions of traffic and exposure to sun.

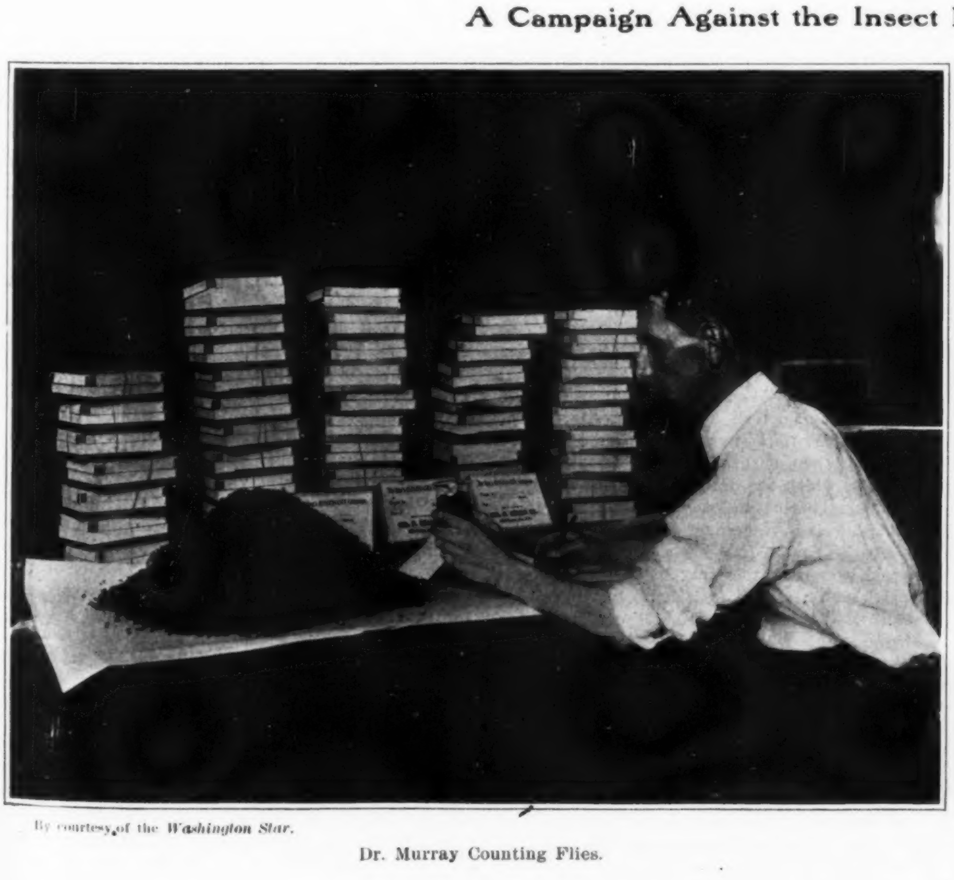
Meanwhile, attempts are being made to remove from coal-tar the substances injurious to vegetation, and to substitute other varieties of tar which contain no such ingredients. The commission has received a number of specimens of such tars, including one which is claimed to be entirely harmless to plants.

The present desideratum is the total suppression of the tarry dust. The application of tar prevents, almost completely, the production of dust by wear of the road, but it is powerless against dust brought by the wind or by vehicles, which can only be kept down by more or less sprinkling. This object could be accomplished more perfectly by mixing "westrumite" or a similar soluble oil with the sprinkling water, and the writer has suggested this procedure to the Paris authorities.

The Wane of the Horse.—Since the introduction of the railroad, but more especially since the automobile has invaded even agricultural activities, says *Cosmos*, the number of horses has decreased very appreciably, and probably nowhere to the same extent as in the British Isles. The number of horses employed in agriculture in Great Britain in 1910 was 1,545,376, showing a decrease of 7,617 as compared with 1909. In the period 1871 to 1881 there were 48 horses upon farms per 1,000 inhabitants; in 1891 this number had fallen to 45; in 1901 to 41, and in 1910 to 38. In large cities, the falling off is even more marked.

Prizes for Catching Flies

A Campaign Against the Insect Pest



By courtesy of the *Washington Star*.

Dr. Murray Counting Flies.

The topic of the fly as a carrier of disease germs has been discussed almost *ad nauseam* in popular magazines and newspapers, so much so that some individuals have even felt it incumbent upon them to raise their voice in defence of the poor fly. Most of us, however, will hardly allow their sympathies to drift in this direction, but will rather endorse and give their moral, if not active support, to such campaigns as that recently instituted in Washington. The *Washington Star*, to which we are indebted for the accompanying illustration, the Associated Charities, health officials, and the citizens themselves, actively pushed forward this movement. Prizes were awarded to children under sixteen years of age who brought the largest number of flies to stations established for the purpose. The use of fly paper had to be barred from the competition, as the flies thus entrapped cannot be counted. That nevertheless the efforts of the school children were rewarded with no little success can be gathered from our illustration, which shows Dr. Arthur L. Murray, of the City Health Department, occupied with the somewhat unenviable task of counting the victims. The word counting must be understood figuratively, it appears, for we observe that Mr. Murray is holding a measuring glass full of flies in his hand.

If the general public could be aroused to wage as it were a perpetual war against the flies, we should no doubt not only be in a large measure ridded of this pest itself, but the general health of the community would be measurably improved. Unfortunately it is a great deal easier to stir up a temporary enthusiasm for a "new idea" than to maintain a permanent spirit of systematic warfare. It is to be feared that the effect of the recent fly campaign at Washington will prove more or less evanescent.

Photographs Upon Watch Lids, Caps and Dials

Practical Instructions for the Amateur

By A. J. Jarman

The making of photographs upon the caps, lids and dials of watches is a class of work different from the usual line of photographic picture making. This branch of photography must be carried out with care at every stage, the actual cost of production being small, as far as the cost of material is concerned, while the results are highly profitable.

The carbon process is the one by far best suited for the transfer to the metallic surfaces, while for dial work, a picture made upon a film of collodion emulsion, carefully prepared, is preferable.

The kind of base must be either gold or silver, or fittings that have been heavily plated. Nickel plated watches with a brass base are not suited, because the chromic salt used for sensitizing the carbon tissue attacks the zinc of the alloy and causes a variable deposit of copper which ruins the print.

The necessary implements required for this class of work are as follows: Three 10 x 12 hard rubber trays, half a dozen 5 x 7, two 4 x 5; a long bellows camera, such as is used for photo-mechanical work, suited for plates 6½ x 8½ and a wet plate holder. This class of plate holder, or dark slide as it is termed, is best suited, because the plate kits can be made to take any size plate from 1¼ x 1¾-inch to 6½ x 8½-inch, the smaller sizes being cut from a 5 x 7 dry plate which will give eight plates of the above small size, which is just suited for the watch cap and dial work.

A prism must be attached to the front of the lens so as to produce a reversed negative. A pair of foot bellows will be required for blowing purposes in the process of matting the caps and lids. Unlike the use of the ordinary camera this one fitted with a prism must be at a right angle to the portrait to be copied and reduced, withdrawing the camera sideways to reduce the size of the image, the focusing being done as usual by extending or closing the bellows, the final focusing being accomplished by the usual ratchet motion. A magnifier must always be used in this class of work, and the finest ground glass focusing screen possible, thus enabling the focusing of extremely small images to be made exact unless the operator's sight is a little defective, then a sharply printed letter in black of moderate size should be placed upon the portrait to be copied, the exact focusing of which will at all times insure a correct and sharp image.

MAKING THE NEGATIVE FOR A CAP OR LID.

Having cut a 5 x 7, ordinary dry plate, such as a Cramer C or any make of like quality, into eight pieces 1¼ x 1¾ by the use of two wood gages so as to give these sizes (thus enabling the cutting to be done in the dark room), place one of these plates in the recess of the kit, adjust this in the dark slide, having previously focused the portrait to the size required, cap the lens, insert the dark slide, remove the cap of the lens, then, according to the intensity of the light, expose with a small stop from five to ten seconds. Now repair to the dark room and proceed to develop the plate in a 4 x 5 tray (kept for this purpose only) with a developer prepared as follows:

STOCK SOLUTIONS.

(A)

Satrapol or metal, ½ oz., av.

Hot water (distilled), 32 ounces, fluid measure.

Shake this until the chemical is dissolved, then add sulphite of soda (dessicated), 2½ oz. av.

(B)

Hydroquinone, 1 oz. av.

Hot distilled water, 32 oz., fluid measure.

Shake this mixture well, then add

Sulphite of soda (dessicated), 2½ oz.

(C)

Carbonate of potash, 8 oz. av.

Warm distilled water, 36 oz., fluid measure.

Each of these bottles must be well shaken until the salts are completely dissolved and allowed to become quite cold before using for developing.

Develop the exposed plate in the following mixture, which may be made up in one solution and used over and over again until exhausted:

DEVELOPING SOLUTION.

Take of A, 2½ ozs.; B, 2½ ozs.; C, 3½ ozs.; add distilled water, 10 ozs., and pour therein 25 to 35 drops of a 10 per cent solution of potassium bromide, made up and kept ready for use by mixing one ounce of potassium bromide in ten ozs. of distilled water.

Pour about three ounces of this developer upon the exposed plate under a deep ruby light in the dark room; cover the tray with a larger one, rock the tray to and fro and sideways, lift the top tray to examine the development, when it will be found if the exposure has been right, that a very clear and brilliant image is being formed. Cover the tray again for a short time, when in the course of about one minute from the commencement, the image will be completely developed.

The miniature negative must now be quickly removed and washed in cold water and placed in a fixing bath, which will render the image beautifully clear and permanent as a negative, after being well washed in running water.

The best fixing bath for this class of negative is made up as follows:

(A)

Hyposulphite of soda, 1 lb. av.

Water, 48 ozs.

Stir the above until dissolved.

(B)

Chrome alum, 1 oz. av.

Dissolved in water, 8 ozs. (fluid).

(C)

Sulphuric acid, 60 drops.

In water, 2 ozs.

Add C to B, mix well, then add this mixture to A. Stir well, allow to stand for two hours, then filter through absorbent cotton. This bath will last a considerable time for fixing small negatives used in an 8 x 10 enameled tray. The negatives must be wiped while still wet with a tuft of wetted absorbent cotton to remove all traces of deposited dirt, then rinse under a gentle stream of water from the faucet and place in a rack to dry, away from all dust.

MOUNTING THE NEGATIVE FOR PRINTING.

The printing frame used for this class of work is a 4 x 5. A clean glass plate 4 x 5 is taken and the miniature negative placed in the center. It is held in position by small strips of gummed paper. Two pieces of paper are now taken, either orange or black, pieces about 3 inches square, a pair of compasses are taken and adjusted so as to describe a circle a little less in diameter than the inside of the lid or cap, upon one piece of paper. The circle is then cut out neatly with a pair of small scissors, slightly curved at the tip, which aids in cutting the circle clean to the line. The next piece of paper has a circle marked upon the center somewhat smaller than the first. As soon as these circles are cut the smallest one is placed upon the front of the glass plate, by a few touches of paste to hold it in position, while the larger circle is placed upon the face of the negative and held there by a few touches of paste. As soon as the paste has dried, the negative must be placed in a retouching frame, face outwards, then with a small stumping brush (an ordinary palette brush, bristles being cut half way down) dipped into a stiff mixture of any opaque color, such as equal parts of yellow ochre, red oxide of iron, and a small quantity of yellow dextrine mixed with hot water, then by dubbing the tip of the brush upon the glass a vignetted effect will be produced all round the head and bust of the miniature portrait, taking care to deepen the color into opacity at the outer edges. The negative is now ready for printing.

PREPARING THE CARBON TISSUE.

Any good quality carbon tissue (obtained from photo supply houses) may be used, such as auto-type engraving black, portrait brown, and sometimes upon a silver surface, Lambertype purple can be employed, but in the majority of cases the portrait brown tissue will be found to answer best. Pieces any size from 5 x 7 to 8 x 10 can be used, employing a 10 x 12 hard rubber tray to sensitize the tissue in.

SENSITIZING THE CARBON TISSUE.

Take bichromate of potash, 2½ ounces; carbonate of ammonia, 30 grains; tie these up in a piece of washed out cheesecloth, then suspend this in 50 ounces of filtered water to which one dram of glycerine has been added. In the course of an hour or less the salts in the cheesecloth will have become dissolved. The solution may now be poured in a clean hard rubber tray and kept cool by setting this tray in another containing cracked ice, if the weather is hot. In winter this is not required. Another clean sheet of glass must be placed upon the work bench in the dark room, size 11 x 14, which can be kept cool by rubbing a piece of ice upon its face for a short time. The cut tissue, which consists of a gelatine film upon a paper support, can be sensitized one sheet at a time, placing it in the bichromate solution, first face down, then after a minute or so face up, taking care that no air bubbles are formed upon the surface, at the expiration of about three minutes, when the tissue lies quite flat in the solution, it must be removed, drained slightly, laid face down upon the cold glass plate then stroked carefully over the back with an India rubber squeegee, first from one end, then from the other, so as to squeeze out the excess of sensitizing solution. A dry rag, or a piece of a well-worn towel must now be used to wipe off all the moisture upon the back of the tissue and from the glass plate. The tissue is now removed from the plate by lifting at one end, clipped with two of the well-known photographic clips, and then suspended from a stretched copper wire to dry, with two wood clips attached to the bottom of the tissue, one at each corner. Several sheets may be sensitized in this way and dried in the dark. When dry they must be kept under pressure in a printing frame upon a sheet of glass, away from all actinic light.

A number of cardboard disks must be cut and kept as gages to cut the sensitized tissue to size. The disk must fit the inside of the circle upon the face of the negative. This is then placed upon a small piece of the sensitized tissue in the dark room, and the latter being cut with a pair of scissors and placed within the circle upon the face of the negative, the negative being marked with the letter T upon the paper mask at the top, the tissue must be marked with a T also at that part so as to indicate the top of the figure when transferred to the lid or cap, otherwise the portrait might be transferred upside down, which would spoil the work. The tissue is now ready to be printed.

PRINTING THE IMAGE.

Place in a separate frame another negative of like quality as to density to the one to be printed from, and put a strip of printing-out paper upon the surface, such as albumen, Solio, or Disco, then place both frames out into daylight in the shade; as soon as the image upon the printing-out paper is about one-third done, both frames must be removed to the dark room, and the carbon tissue disk removed and placed in a box away from light until ready for development. If several portraits are to be made they should be made and placed in the box as soon as possible because a number of prints can be developed at the same time. The development must not be delayed for too long a time because the action of light continues even in the dark, when the carbon tissue has been exposed. The cap or lid must be prepared to receive the carbon image, the surface of the metal will require to be matted; this aids in giving a tooth to the metal, thus enabling the carbon image to adhere.

MATTING THE SURFACE OF THE CAP OR LID.

For the purpose of matting, a small bellows must be used, operated by one foot. The bellows best suited are those used by jewelers for use with a blowpipe. The pressure of air is considerable; this is necessary to drive the pumice powder in a dry state against the surface of the metal. The vessel for holding the fine pumice powder is shown at *A*, Fig. 1. This vessel consists either of a copper ball or a tin cylinder, with a three-eighth inch diameter brass pipe soldered at one end, over the left end of which a rubber pipe is placed and connected to the exit pipe from the foot bellows, *B*, Fig. 3. A tapered nozzle is soldered at the opposite end of *A*, Fig. 1, whence the air and the pumice powder issue. A conical loading inlet, *C*, Fig. 1, is used for charging the vessel with pumice powder.

The vessel must not be more than half filled with very fine pumice powder, known as FFF, which must be perfectly dry. The matting is best done over a banker, as it is called, which is made like a shallow box, with three sides, two feet square at the bottom and the sides 9 or 10 inches high, as shown in Fig. 2. The cap or lid must be quite free from grease; the fingers must not be allowed to touch the surface to be matted. The exit air pipe of *B*, Fig. 3, is connected by a flexible tube to the left inlet pipe of *A*, Fig. 1.

MATTING THE SURFACE.

The lid or cap must be taken in the left hand, the surface to be matted facing the nozzle and held about six inches from it; the bellows are set to work generally with the right foot. The air passing over the pumice powder carries some with it, the supply being kept up by jogging the copper ball on the bottom of the banker. The vessel is held in the right hand, the air blast being directed upon the metal surface, and the cap or lid must be moved about, so as to secure even matting all over. The banker must be placed near an open window, to allow a free current of air from the room to pass out, and thus carry the superfluous dust away. The main portion of pumice powder will remain in the banker and can be used over and over again.

As soon as the matting is complete, the excess of

pumice is blown off by the mouth and carefully wiped with a tuft of clean absorbent cotton. As many articles as desired are treated in this manner, then one by one rinsed under the faucet, and finally cleaned by dipping each in a strong cold solution of caustic soda kept ready in a small pie dish for use at any time. The article is held with great care by a pair of small flat-nose pliers or tweezers, the wiping being accomplished by using a mop made by pressing a tuft of absorbent cotton in the end of a five-inch length of stiff vulcanized rubber tubing. This mop will resist the action of the caustic soda, the cotton being changed occasionally. As soon as the article has been cleaned,

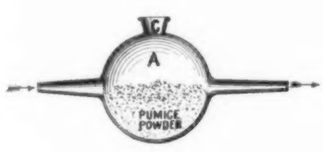


Fig. 1.

it must be rinsed in running water under a faucet, then placed in a tray of clean water without being allowed to dry. In all the operations with this class of work, the faucet must have a lump of absorbent cotton tied over the nozzle with four thicknesses of cheese cloth. This precaution will prevent any dirt, chips of iron rust, and organic matter from striking and adhering to the gelatine image. This precaution must not be omitted. Make up a solution of half a pound of white granulated sugar in eight ounces of boiling water, stir well until the sugar is dissolved, allow it to stand for several hours to cool then pour off the clear portion free from dirt. Pour some of this into a 4 x 5 tray. Take the exposed tissue disk, place it into a 5 x 7 tray of clean cold water, allow it to remain until it lies quite flat, dip this into the sugar solution, also the lid or cap upon which it is to be placed. Lay the tissue disk face down upon the lid, drain the excess of liquid into the sink, then with the thumbs of both hands press the tissue firmly down upon the metal, stroking it at the same time from the center to the outer edge; or this may be done with a tapered piece of India rubber about three inches long, the kind used by draftsmen in rubbing out the pencil lines in drawings. In this case, a small disk of thin India rubber sheeting must be placed upon the back of the tissue, the rubbing then taking place from the center. Allow the carbon tissue print to remain for about ten minutes before developing; this will insure complete contact.

DEVELOPING THE IMAGE.

Place in a 10 x 12 tray some warm water, lay the caps or lids with the tissue attached into this, move each one about in the warm water. Increase the temperature by adding a little more hot water (remove the caps or lids when this is added), return them to the tray. In the course of a minute or two the paper backing of the tissue will float off; remove this from the tray, take hold of one of the lids, move it to and fro in the warm water, treat each one alike, when in the course of a few minutes the image will become fully developed, standing in relief, which will not be so manifest upon drying down, the print while still wet must be placed in a five per cent solution of common alum for two minutes, after it has been rinsed under the faucet in a gentle stream of water. From one to two minutes will be long enough in the alum bath. The print must now lie in clean, cold water for a few minutes, then be rinsed in running water to rid the film of any free alum, then be stood on edge to dry, upon clean blotting board. When quite dry the prints must be coated with a protective varnish for the preservation of the image. The best varnish or lacquer to use is known as amyl acetate collodion, sometimes called banana oil. This material can be purchased at any wholesale chemists in small quantities from half a pint or a pint. A small quantity of amyl acetate should be purchased at the same time to be added to the collodion to thin it down slightly when it becomes too thick, owing to evaporation.

VARNISHING THE IMAGE.

As soon as the image is perfectly dry, a small quantity of the collodion must be poured upon it and allowed to flow all over evenly. The excess may be allowed to drain into the stock bottle for a minute because this collodion is very thick and sluggish in flowing.

The last drops are best removed by using some strips of blotting board about a quarter or three-eighths of an inch wide, one end being torn diagonally so as to present the best absorbing surface. As soon as the surface has been thus drained, the cap or lid can be stood on edge upon dry blotting board and left to dry spontaneously, or the drying may be forced by waving over a smokeless gas flame, or upon an electric heater. In the last case the article must be watched so that it does not become overheated.

When the coating has become set the work is complete. Of course these caps and lids must be removed from the watch to enable the photographic work to be performed. The pivot or pin should be removed by a watchmaker unless the operator possesses suitable tools. The usual charge by a watchmaker for removing the pins of either a cap or lid and replacing the same is ten cents. Should any spotting be required it must be done before the coating of collodion is applied. When the coating of the image is property done it will be both acid and alkali proof, and thoroughly effective against damp and perspiration.

MAKING PRINTS FOR TRANSFER TO A WATCH DIAL.

The miniature negative for this class of work is an ordinary one, not reversed, the film being entirely of collodion. In this kind of photography the sensitive collodion emulsion must be made up and the paper coated by the operator.

THE COLLODION EMULSION.

Make up the following in separate bottles. The final bottle in which the mixing is done must be an amber colored one:

(A)

Pyroxyline (gun cotton), 50 grs.
Pure photographic alcohol, 4 fluid
Sulphuric ether, 4 fluid ozs.

(B)

Nitrate of silver, 240 grs.
Distilled water, ½ fluid oz.

(C)

Chloride of strontium, 64 grs.
Pure alcohol, 2 ozs.

(D)

Citric acid, 64 grs.
Pure alcohol, 2 ozs.

Into an amber-colored bottle filter two ounces of A, add thirty drops of B in one dram of alcohol, shake this mixture well. Now add one dram of C, a few drops at a time, and thirty drops of D. The mixture must be vigorously shaken, then filtered through a small tuft of absorbent cotton pressed lightly in the neck of a small glass funnel, covering the funnel with a glass plate to prevent the evaporation of the ether. The filtering must be carried out in the dark room away from actinic light, in an amber-colored bottle.

This emulsion will keep fairly well for some time previous to use. The paper upon which this emulsion is to be used must be prepared in the following manner: A number of sheets of baryta-coated paper about 8 x 10 must be prepared previous to coating with the emulsion. They will keep without deterioration for a long time.

THE STRIPPING PAPER.

Float the sheets of baryta-coated paper upon the following mixture while warm:

Gelatine, 90 grs.
White granulated sugar, 30 grs.
Distilled water, 6 fluid ozs.

Cut the gelatine into small pieces, allow them to soak in the water for fifteen minutes, adding the sugar at the same time. Then place the vessel into

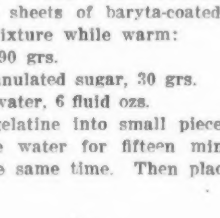


FIG. 3.

a saucepan of hot water, stir until the gelatine has melted, filter through two folds of cheesecloth. About one minute will be the time for coating, when the paper will lie quite flat. Remove and suspend it with a wooden clip at one corner, to dry in a suitable closet away from dust. When the sheets are perfectly dry they may be kept quite flat by keeping them in an 8 x 10 printing frame under pressure until required for use.

COATING THE STRIPPING PAPER WITH EMULSION.

Cut one of the 8 x 10 pieces of paper in half, turn up the edges about a quarter of an inch all round, forming a lip at one corner, then fasten this down upon a small sheet of stiff cardboard with a few touches of hot sealing wax. In the dark room pour some of the emulsion upon the paper, allow it to run all over. Perform this quickly, then drain the excess of emulsion into the stock bottle and suspend it to dry away from light, without removing from the cardboard.

The drying will be complete in about ten minutes, then coat the paper again, this time draining the emulsion from the opposite corner. After drying the second time, remove the paper from the cardboard, trim off the edges with a pair of scissors, and pack away face to face in a 5 x 7 printing frame until required for use.

The negative for a watch dial photograph is made the same as for the carbon print, not reversed, the head and shoulders of the person being very small, so as to occupy a space of an oval about half of an inch wide and one inch long. This size of paper can be much better handled than smaller sizes.

Place this upon the negative in a printing frame and print either in direct sunlight or in the shade.

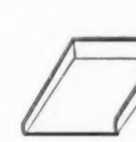


Fig. 2.

When the image is printed about two or three shades darker than required when finished, remove the sheet of paper from the frame and cut the figure out to the size of oval required, leaving a tapered tail piece attached resembling the shape of a tadpole. This tail piece is to enable the print to be handled with a pair of tweezers, for, being so small it cannot be handled with the fingers.

The print must now be washed in several changes of water, then toned in a chloride of gold and borax bath made up as follows:

Chloride of gold, 2 grs.
Water, 30 fluid ozs.
Saturated solution of borax, 4 fluid ozs.

About four ounces of this solution is employed in a 4 x 5 tray. The toning of the print should be carried up to a purple brown color. It is then washed for a short time in running water and fixed in a weak solution of hyposulphite of soda, as follows:

Water, 10 ozs.
Hyposulphite soda, 1 oz.

Five or six minutes in this will completely fix the print. It must now be well washed in running water for fifteen or twenty minutes. The washing of such small prints is best effected by placing a 5 x 7 piece of glass over the top of a small pie dish, allowing space only for the water to drizzle into the dish, its escape being effected by pressing out between the glass plate and the top of the dish.

When the washing is complete the print can be transferred to the dial. Assuming that the portrait is to be placed under the figure twelve, the bottom part of the figures on the dial must be removed, to allow room for the picture. This is done by dipping the tip of a struck match, or a thin strip of gutta percha into hydrofluoric acid and touching the part to be removed, and quickly wiping it with a small tuft of absorbent cotton, previously wetted and wrung out, then rinsing in clean water. The toned and fixed print must now be placed in a basin of warm water, the tail piece being cut off. In the course of a minute or two the collodion film will loosen, then the dial must be placed in the warm water and the film carefully made to slide off the paper by the use of a small fitch brush and adjusted in position. The trace of gelatine sugar compound will be enough to hold the film to the dial. The excess of water is pressed out and the film held in position by carefully holding the sides with the thumbs of both hands, then pressing the tip of the tongue upon the film. It must now be allowed to become quite dry, when it can be affixed permanently by coating the dial all over with amyl acetate collodion, allowing the excess to drain off upon thick blotting paper, and dried in a closet away from dust. When dried, the photograph will present the appearance of being burned in. The coating of the dial will in no way interfere with its being refitted. The figures upon the dial will appear more brilliant than they did before varnishing. Should the negatives require intensifying after development to secure greater opacity in the high lights, the following solution will be found to act perfectly.

(A)

Intensifying Solution.

Bichloride of mercury, 60 grs.
Bromide of potassium, 60 grs.
Hot distilled water, 16 ozs.
Allow to become quite cold.

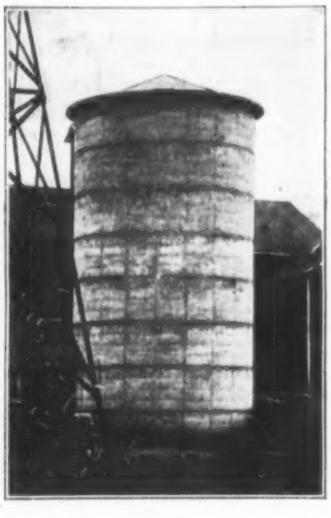
(B)

Sulphite of sodium, a saturated solution, about 16 ozs.
Citric acid, dissolved in half an oz. of water, 30 grs.

Place the negative into the mercury solution, let it bleach clean through the film, wash it well for five minutes, place it in a tray, and pour the B solution upon it, rock the tray to produce even color, allow the parts to blacken through, wash well, then place in a rack to dry.

Silage and Concrete Silos

How Farmers Are Building Solid-Wall Silos



Solid Concrete Silo With Concrete Roof.

The principal source of profit in dairying, stock-raising and farming, lies in improving the quality and at the same time keeping down the cost of production. In this matter of profit and loss nothing plays such an important part as the question of feeds and feeding. The natural feed for animals, the one on which they do best, is green pasture. In climates subject to frost, man has made the same provision for animals as for himself by providing them in winter with canned green fodder called "silage." Silage is made most commonly from corn, cow peas, clover, sorghum, or alfalfa, merely chopped fine and stored in large water-tight cans known as "silos." In dry weather or in winter, when green pasture cannot be had, this feed is equally good in producing a flow of milk or in putting fat on animals. One acre of a crop harvested as silage will feed twice as much stock as the same amount harvested in any other manner.

Like a glass fruit jar, a silo must be watertight and jointless to keep the silage from molding or "dry firing." For this reason, and also because no painting or repairing is ever necessary, solid-wall concrete silos are coming into general use.

SELECTING THE SIZE OF THE SILO.

The best silos are built circular in shape. The size depends upon how many animals are to be fed daily, the quantity in pounds for each animal's daily feed, and the number of days it may be necessary to feed them. The silo should be of such size that a layer of silage at least 2 inches in depth will be removed each day after feeding has begun. This prevents a thin top layer from molding. A dairy cow requires about 40 pounds of silage per day, and the following table is based on this amount. Forty pounds is also the average weight of a cubic foot of silage.

DIMENSIONS OF SILO ACCORDING TO SIZE OF HERD.

Number of Cows in Herd.	Feed for 180 Days.				Feed for 240 Days.			
	Estimated Tonnage of Silage Consumed.	Size of Silo.		Corn Acreage Required at 15 Tons to Acre.	Estimated Tonnage of Silage Consumed.	Size of Silo.		Corn Acreage Required at 15 Tons to Acre.
		Diameter.	Height.			Diameter.	Height.	
	Tons.	Feet.	Feet.	Acres.	Tons.	Feet.	Feet.	Acres.
10	36	10	25	2½	48	10	31	3½
12	43	10	28	3	57	10	35	4
15	54	11	29	4	72	11	36	5
20	72	12	32	5	96	12	39	6½
25	90	13	33	6	120	13	40	8
30	108	14	34	7½	144	15	37	10
35	126	15	34	8½	168	16	38	11
40	144	16	35	10	192	17	39	13
45	162	16	37	11	216	18	39	14½
50	180	17	37	12	240	19	39	16
60	216	18	39	14½	288	20	40	19
70	252	19	40	17	336	..	..	..

It is frequently advisable to cut down the average daily ration or to use silage together with other feeds. With this thought in mind, and especially for dry weather feeding in summer, many farmers find it best to build two silos of moderate size instead of one large structure.

LOCATION AND FOUNDATION.

Locate the silo where it will be convenient for feeding. Usually it is joined to the barn by means of a chute and passageway with doors. Since the silo and its contents are heavy, it must be built on solid ground. The bottom of the foundation should go below frost line. The silo may, with advantage, extend 4 to 5 feet into the ground. Dig the pit large enough to allow for the thickness of the circular walls and a footing 2 feet wide.

MAKING THE FORMS.

In order to save lumber the concrete is poured into forms which can be moved up as the concrete sets or becomes hard. These movable forms consist of two circular shells 3 to 4 feet high, so made that one fits within the other with space between for a 6-inch wall. The horizontal framework consists of 2 by 4-inch timbers cut to a circle, which are covered with sheet metal or wooden lagging. Each piece must be long enough to provide for a 6 foot 3-inch length of the circumference of the circle as well as several inches for the lap or strap joints. The forms are raised by loosening them at the joints and setting them up again on the finished section of the silo.

MIXING AND PLACING THE CONCRETE.

Concrete for silos should be rich in Portland cement and should be put into the forms mushy wet. Mix it 1 part cement to 2 parts sand to 4 parts crushed rock. Four parts of clean pit or bank-run gravel may be used instead of the sand and rock. Measure all materials on the basis that 1 bag of cement equals 1 cubic foot. Many persons raise the concrete in buckets, but the work can be done more quickly and easily by using a horse together with a derrick or a well braced jib-boom fixed to an adjoining building.

BUILDING THE SILO.

The finished silo shown above is 15 feet in diameter (inside) and 36 feet high, of which 4 feet is below ground. At odd times all of the materials were hauled, so that there would be no delay when the work was started. After the pit was dug to solid clay, the concrete footings (2 feet wide and 1 foot thick) were placed and a 4-inch concrete floor was laid upon the natural clay bottom. The next day the forms were set up, the reinforcement placed, and the walls begun. These forms were 4 feet high and were made in eight sections 6 feet 3 inches long.

Since silage contains so much water, steel rods are necessary as reinforcement to withstand the pressure. To get the best results, this reinforcing should be placed exactly 1½ inches from the outside of the silo wall. Rods ⅜-inch in diameter and 10 feet long were used. The vertical rods were spaced 18 inches apart. Measuring down from the *top of the silo*, the horizontal rods were spaced as shown in the tables below.

SPACING OF HORIZONTAL REINFORCEMENT.

Feet distant from top....	40-35	35-30	30-25	25-20	20-15	15-10	10-0
Spacing, in inches..	6	7	8	10	12	15	18

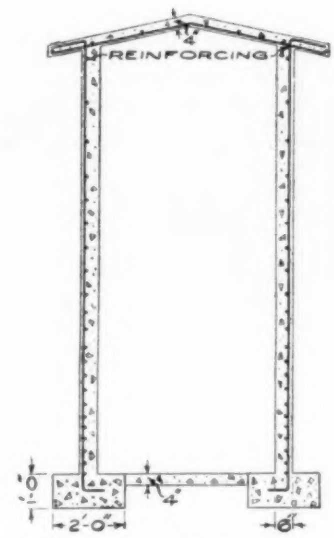
The horizontal rods were carefully made into solid hoops by bending the ends so as to hook together. They were also wired to the inside of the vertical rods. (Complete plans for silos may be obtained free from any Portland cement company.) Two extra lengths were placed in the concrete 1½ inches above the door openings for removing the silage. These openings were made by a removable form (also cut to the circle), which fitted snugly between the molds for the silo wall.

The silo forms were filled with concrete and allowed to stand over night. The next morning they were loosened, raised and again filled. These operations were repeated daily until the side walls were finished.

With a 4-inch concrete roof, the silo is entirely fire and repair-proof. The roof was built on a temporary wooden roof, which was entirely removed after three weeks. The concrete roof is cone-shaped with a rise in the center of 2 feet and a drip or overhang of 1 foot. One inch from the under side, this roof is reinforced with ⅜-inch rods laid like the spokes of a wheel and spaced 18 inches at the rim. Every other rod reached only halfway to the peak of the roof. To hold the spokes in position so that the concrete could be forced between them and the temporary wooden roof, one ring of ⅜-inch rods was wired to this reinforcing just over the side walls and another halfway to the peak. These rods strengthen the roof greatly and must not be left out. Water-soaked weather boards were used to form the circular edge of the roof. An opening for the blower tube from the cutter was formed in the silo roof in the same manner as the doors in the side walls.

THE COST OF CONCRETE SILOS.

The list of materials required for this silo is given below together with a very liberal estimate of the cost of the same. The silo was built by five farm laborers in thirteen days. As a raise was made each day, the four extra days were spent in framing the forms, digging the pit and building the roof. The owner used gravel from his farm pit instead of stone and sand.



Section of Concrete Silo Showing Reinforcing.

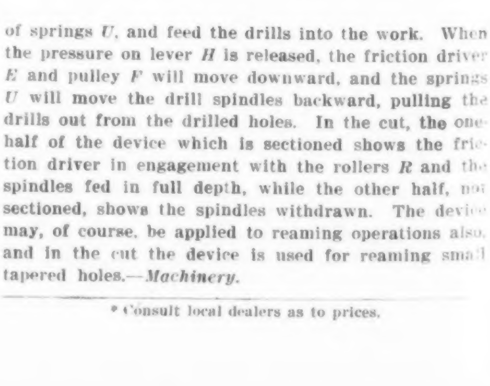
BILL OF MATERIALS.*

Crushed rock, or screened gravel	40 cu. yds. at $1.10	$44.00
Sand	20 cu. yds. at $1.00	20.00
Portland cement..........	54 barrels at $2.50	135.00
Reinforcing, 425 pieces of ⅜-inch x 10-foot rods	1564 pds. at $0.02¼	39.10
		$238.10

The *first* cost of concrete silos may or may not be greater than that of the best of any other kind. The time is now at hand when farmers, like railroads and corporations, are considering the lasting qualities of buildings. Concrete silos need no insurance; they do not blow down or burn up. They never have to be painted or repaired. With other kinds of silos during their short lives, these expenses alone equal the first cost. Concrete lasts forever.

A New Multi-Spindle Drill.

In the *Zeitschrift für Werkzeugmaschinen und Werkzeuge* is shown a device for drilling simultaneously a number of holes radially in a piece of work. The work K is held in the collet I. The device is driven by a belt on pulley F, which is cast in one piece with a friction driver E. The pulley F with the friction driver E is raised up by means of lever H to engage with the friction rollers R, located on the drill spindles. By continued pressure on lever H the friction rollers are pressed inward against the action



of springs U, and feed the drills into the work. When the pressure on lever H is released, the friction driver E and pulley F will move downward, and the springs U will move the drill spindles backward, pulling the drills out from the drilled holes. In the cut, the one half of the device which is sectioned shows the friction driver in engagement with the rollers R and the spindles fed in full depth, while the other half, not sectioned, shows the spindles withdrawn. The device may, of course, be applied to reaming operations also, and in the cut the device is used for reaming small tapered holes.—*Machinery.*

* Consult local dealers as to prices.

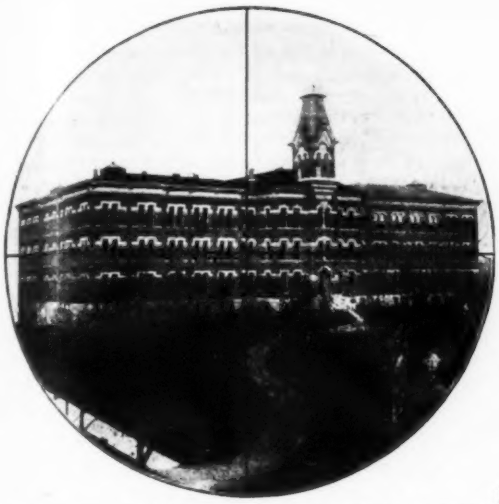


Fig. 1.—The Creighton University, a "Field of View" in a Telescope.

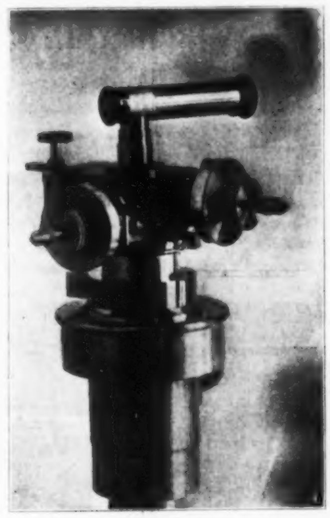


Fig. 3.—Photograph of Whole Eyepiece of Transit Taken Out of the Telescope, Showing the Micrometer Box With Its Two Screws.

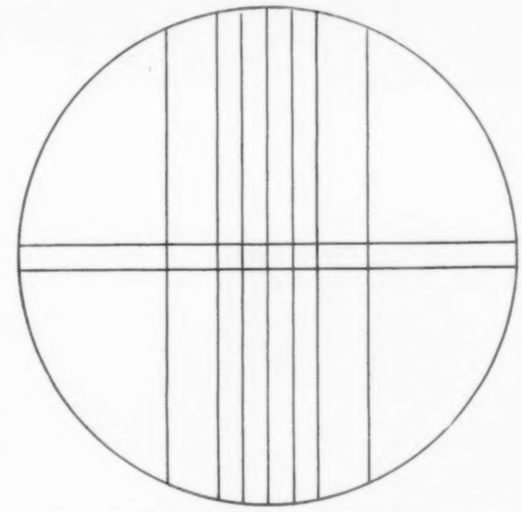


Fig. 2.—Reticle of Transit, Consisting of Seven Vertical and Two Horizontal Threads or Wires, Each System Being Moved by a Micrometer Screw.

The Value of a Cobweb*

How a Damaged Spider's Thread Paralyzed An Entire Department

William F. Rigge, S. J.

We have often been told of the value of what are generally called trifles. We know that very great things often depend upon very small ones that, for example, the lives of many people and the safety of tons of precious merchandise may be endangered by the neglect of a bolt on a bridge, and that a spark may cause the conflagration of a city or of miles of forest lands.

While we know these things and willingly admit them, and can give illustrative examples of our own, I think most of my readers would imagine I was drawing the long bow when I tell them that a sixteen-hundred-dollar instrument was thrown completely out of use for the want of a cobweb! Yet, it was a sober fact, and was painfully in evidence to me no less than to some students of mine, one of whom had come 750 miles principally in order to use this instrument. It was about as serviceable to us as its picture would have been; and all that on account of an accident to the cobwebs it had contained. Let me explain the mystery.

THE WIRES OR THREADS IN A TELESCOPE.

If the reader has ever looked through a telescope that was on a measuring instrument such as a surveyor's transit or level, he will surely have seen in it at least two fine black lines crossing each other at right angles, one being vertical and the other horizontal. The object of these lines is to enable the observer to direct his telescope very accurately upon a given object, or conversely to find the object his telescope is directed to when it is adjusted by means of its levels or circles. The whole round picture seen in a telescope is called its field of view. As this is of some considerable size and shows quite a number of objects, it would be impossible to know which of these objects the telescope was directed to, unless we had these fine lines to point it out to us.

A telescope, as we probably know, consists essentially of at least two lenses, one at each end of a tube, each lens being itself a compound of two or more simple or elementary ones. The lens nearest the object looked at is called the objective, and is always the larger of the two. This lens forms near the other end of the tube an image of the object, in exactly the same manner that a photographic camera does. In fact, as far as the objective is concerned, there is no difference between a telescope and a camera, both have the same kind of an objective mounted at one end of a tube or box, the first having generally a cylindrical or converging tube so as to have a small field of view, and the second a diverging or expanding box so as to have a large field of view.

In the photographic camera we place a sensitized plate where we see the image of the object on the ground glass, and thus secure this image by the photographic or chemical action of the film. A photographic telescope is purely and simply a photographic camera, only that it is generally longer, that is, has a longer focus, and thus gives a larger picture.

In a visual telescope the image is looked at through an eyepiece, which is the second of the two lenses we mentioned before, and derives its name from the fact of its being nearest the eye of the observer. This eyepiece is a magnifying glass in principle, and makes the image look larger. It is often easily removable and replaceable by another, which has a different magnifying power, so that one may examine the object he is looking at under various degrees of magnification. The higher the power, the fainter is the image, because the eyepiece receives only a definite amount of light from the objective, and the more the image is magnified, the more this light is spread, so that the highest powers of a telescope can seldom be used to advantage except on a bright object and in a clear sky.

CHARACTER OF THE LINES.

The fine black lines we have mentioned before are at the same place in the tube where the objective forms the image, so that both image and lines are viewed together through the eyepiece. For very accurate work it is evident that these lines should be very fine and smooth, so that they may be looked at through eyepieces of the highest magnifying power. They ought also to be perfectly straight and taut, and sufficiently elastic to remain straight and taut, no matter how much the tube of the telescope and the frame on which they are fixed, expands and contracts with the temperature, or is moved about in various positions. And lastly, they should not be hygroscopic, that is, should not be affected by wet weather.

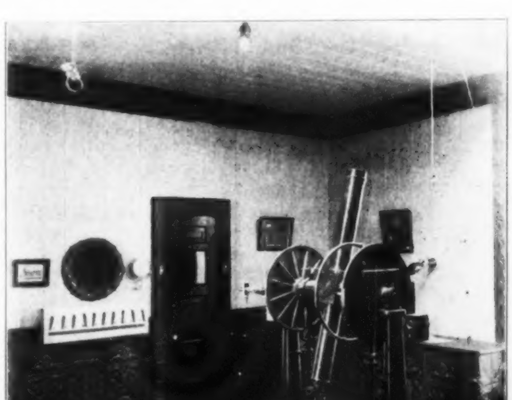


Fig. 5.—The Sixteen-hundred Dollar Transit Instrument, Which Was Rendered Perfectly Useless for the Want of a Few Cobwebs.

COBWEB.

Very few substances possess all these qualifications in a higher degree than the commonest kind of cobweb, simple ordinary spider's web, which tidy people abhor so much in the corners of their rooms. A spider line is perfectly smooth under the highest magnifying power. It is perfectly black in a bright field, and may be made bright in a dark field. It is also elastic, and may therefore be stretched perfectly straight, its weight being so insignificant that in short lengths there can be no danger whatever of sagging.

Cobweb is inexpensive, to be sure, but so delicate, that it is quite an accomplishment to know how to handle it. Perhaps the reader would like to know how this is done, and how spider lines are actually put into a telescope.

HOW SPIDER LINES ARE PUT IN.

The first thing to do is to get the cobweb. This is not as easy as it looks. Not every spider gives a web that can be used. Some lines are altogether too fine to be readily seen even with a magnifying glass, and too trying on the eyes. Some consist of loose strands not sufficient knit together, they are not one line but many of them and absolutely unfit for the purpose. Some have beads strung upon them, or are otherwise of varying thickness. It took us actually a whole week to find the cobweb we wanted. This may be a powerful proof of the cleanliness of our buildings and premises, but it was a fact notwithstanding, and was responsible for 90 per cent of the inactivity of our telescope.

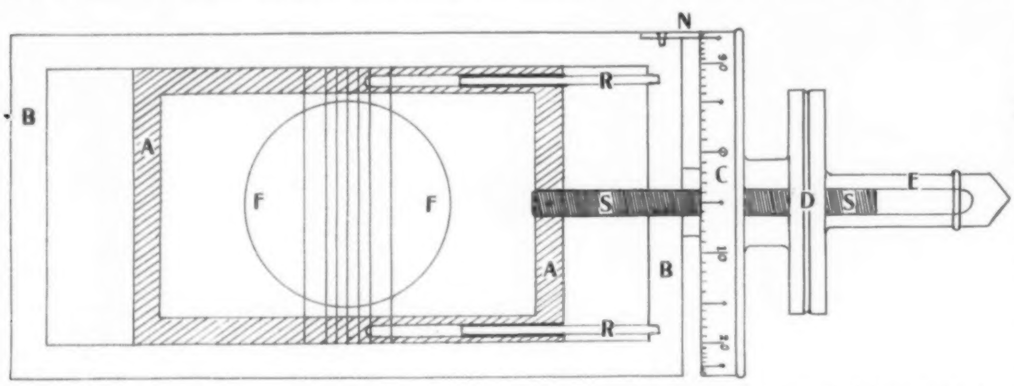
When the right spider has been found, his thread is caught as he spins it and before it touches anything, and wrapped on a branching twig or stiff wire shaped liked the letter Y. Having then made ready the frame work on which the threads are to be fastened, we take a compass or dividers, such as is used for drawing circles, put a drop of shellac or other sticky substance at the points, and pick up a suitable spider line longer than is finally needed. Stretching this by opening the compass a trifle, we place the line in position, using a magnifying glass if necessary, and press it down so that it touches the shellac we have placed on the outside, on the lateral sides as we might call them, of the frame work, make sure that it is caught there, and cut it off with a penknife. We next put the second thread in position in the same way, and all the others that we may need. We then with a clean pin or needle adjust them cautiously under a magnifying glass, and when everything is satisfactory we drop a little shellac on all the threads on the front side of the frame work, and the job is done.

DIFFICULTIES.

Yes, when everything is satisfactory—has the reader ever tried it? We think not, for it takes a long time and infinite patience before everything is satisfactory. Cobweb is extremely delicate. The least false movement will tear the thread. Removing the lose ends may ruin two or three neighboring threads. Patience, try again. Sometimes the final drop of shellac may be too wet with alcohol and may so affect the threads that they curl up and stick together. Unraveling then is almost sure disaster. Flies must not witness the

* By cortesey of *St. Michael's Almanac.*

work, for they may spoil the threads directly as well as indirectly by annoying the operator. A breeze is almost as objectionable. Altogether it is as trying a piece of work as one could well imagine, trying to hands and eyes and much more so to patience. The material is not worth much, but the skill is, and when one has tried it for the first time, he will admit that the two dollars that a professional instrument maker charges in his catalogue for only two threads at right angles, are far from being an unfair price. But if there had to be nine wires, one hundredth of an inch apart, what would the charge be then? That was exactly our case. And we did not have the time to send the eyepiece to a professional and wait for its return, whatever the item of cost might be.



The framework A, which carries the reticle, is moved in the box B by means of the Screw S, which has a hundred threads or turns to the inch. The nut, head or drum C of this screw is divided into a hundred parts, tenths of which are indicated by the pointer N. The reticle is moved slowly by turning the milled head head D, which forms one piece with the drum C and the shank E. Turning the shank E moves the reticle rapidly across the field. RR are two rods supporting long spiral springs, which push the framework A away in the opposite direction, when the screw is turned backward. These springs are strong enough to hold the reticle firmly in any position. F is the field of view. The number of whole turns is indicated by a cogwheel gearing into a short spiral screw on the lateral face of the drum. It is not represented on the diagram.—There is a second and similar micrometer at right angles to the one shown. It moves two parallel horizontal threads, which are supported by two short rods or studs, and brought as close to as possible without touching the seven vertical threads, so as to be in the same focus with them.

Fig. 4.—The Micrometer for Adjusting and Reading the Position of the Reticle.

PLATINUM WIRES AND RULED GLASS.

Spider lines are so delicate that some makers use very fine platinum wires. One of the greatest firms in the country says in its catalogue: "No one but a workman with practiced hand and provided with the best facilities can properly set the platinum wires in a cross-wire diaphragm, and it is useless, therefore, for us to send a parcel of wires for that purpose." Platinum wires are, however, harder to set close and parallel and straight, than spider lines. They may be more durable, although our cobwebs were all that could be desired for 21 years, until they were destroyed by an accident. This accident consisted in one of my students inserting an eyepiece that was scarcely ever used. The lens went into the tube too far and tore two of the threads. These could not be replaced without renewing the whole set, or reticle, as it is called. Whatever fault there was, ought to be laid upon the instrument maker, who should have prevented such a possibility. If it was the student's, he nobly made amends for it by spending a whole week upon the new reticle, and finally delivering one in every respect as good as the one he had injured.

Some makers use ruled glass. But glass intercepts some light, and may become soiled by age or dust, when it would be difficult to clean. Whatever its advantages may be, it could not be used in our instrument on account of its peculiar construction, as its maker himself personally affirmed. I have never yet found anything superior to common spider's web.

USES OF A RETICLE.

The spider lines in a telescope serve also other purposes besides merely indicating the center of the field of view by means of a simple cross. When there are many wires, as there are in every astronomical transit, the exact fraction of a second that a star crosses them is carefully noted. Knowing the intervals between the threads, we can reduce the observed transits to the middle wire, and thus practically have as many chances at the middle wire as there are threads in the field.

MICROMETER.

And again, by having the whole reticle, or at least one wire of it, movable, we can place a thread wherever we please, and thus observe and measure the positions of stars or objects anywhere in the field of view, in the Creighton University transit the whole reticle is moved by means of a screw which has a hundred threads or turns to the inch. The head of the screw is divided into a hundred parts, and these parts are read by estimation to tenths, so that we may measure down to one-tenth of one-hundredth of one-hundredth, that is, to one hundred-thousandth of an inch. There are two such micrometer screws in the eyepiece, one moving the seven vertical threads, and the other the two horizontal ones. Their accuracy is such that one could measure inches on a stake 80 miles away.

The finely divided circle on this instrument is read by two micrometer microscopes, which also use spider lines. These came with the instrument 25 years ago, and are so well protected that there is no likelihood of their ever being damaged.

The detailed construction of the micrometer can be gathered from one of the accompanying illustrations.

IMPORTANCE OF THE SPIDER LINES.

All the refinements of this sixteen-hundred-dollar instrument were lost on account of the want of the few cobwebs which constituted its reticle. Stars could not be timed, the micrometers had no employment, and the circle could not be used. Nor is this all. Several connected instruments were rendered idle. The chronograph, upon which star transits are recorded, and the sidereal and solar clocks as well, were all out of commission on account of that apparently most insignificant accident to a few cobwebs. Even our great equatorial telescope was only a seeing instrument, and had lost a great part of its power of measurement, because the error of our time-pieces could not be ascertained. In a word, it was an actual fact, and, as I said, painfully in evidence, that all measuring power of our observatory was ruined on account of the want of a few cobwebs. It was a great object lesson, which the reader may turn to his profit in his own way, and thus form a much higher estimate than he has ever done before of the value of trifles, and especially of the value of a cobweb.

Creighton University Observatory, Omaha, Neb.

Wasted Mathematical Energy

The Futility of Some Efforts of the Amateur Mathematician

The thirst for truth and the impulse to accomplish the solution of problems are human traits that can hardly be too strongly encouraged. The greater pity is it that occasionally a man thus endowed turns his faculties into barren channels, and seeks to achieve the impossible. There is the perpetual motion crank, who imagines that he can construct a machine that will yield up an unlimited amount of work for nothing; others, of a less mechanical turn of mind, bury themselves with certain outstanding problems of mathematics. The case of the latter is ably discussed in the *Queens Quarterly* by N. F. Dupuis, who shows clearly the nature of the insurmountable obstacles which stand in the way of the solutions sought. It is not so much that the "trisection of the angle" for example is impossible, but that it requires auxiliaries beyond the two admitted by Euclid—the straight line and the circle. But we will let Mr. Dupuis state the case in his own words:

The average man is not a mathematician, except in the lowest and most fundamental portions, and does not, with very few exceptions, pretend to be; possibly because there is nothing in the subject calculated to excite his cupidity or to lead to his preferment. The mathematical attainments of the man of the street consist usually of a small amount of arithmetic sufficient for the common transactions of business, possibly a remote knowledge of elementary algebra, and a meager acquaintance with the elementary principles of geometry. When it comes to the higher branches of the subject, he is usually ignorant of even the nomenclature and notation, and his speculations in this field are more likely to be wrong than right. But this statement has some peculiar partial exceptions. Some people, believing themselves to be mathematicians, overrate their mathematical powers to the extent of assuming that it has been reserved to them to find solutions to those famous "problems" which have been handed down from ancient times and which have so far appeared to baffle the mathematical world. Such are the *Trisectors of the Angle, the Duplicators of the Cube*, and the *Squarers of the Circle.*

The accomplished mathematician long ago proved to his own satisfaction that the trisection of an angle by the machinery of Euclid's elements is an impossibility. And that being for once established there is no reason, but rather folly, in his returning to the problem again, or in seeking to discover errors in the attempts of others along this line. The results of mathematics are absolute, and there is no more sense in trying to trisect an angle by Euclid's figures than there would be in attempting to prove that the sum of 2 and 3 is 6. The mathematician knows too well the limitations of his work, and the futility of spending time over that which cannot lead to any definite result. In fact, the "problems" in question have long ago ceased to be problems to the mathematician inasmuch as he knows exactly under what conditions they admit of solution and the means necessary to be employed in their solution. As the carpenter would find it impossible to bore a round hole through a plank if supplied with a hammer alone, but would experience no difficulty when furnished with an auger, so somewhat in like manner these problems become impossible of solution when restricted to the employment of certain fundamental principles, but yield easily enough when all restrictions are removed. It is considerations of this kind that have influenced the writer in preparing the present article. If it has any effect in preventing the waste of time and energy and money in following after a mere chimera, it will do some good.

Let us consider first the *Trisection of an Angle.*

This famous old problem has come into our mathematical horizon as a curiosity rather than as a problem to be solved. The older mathematicians gave a great amount of thought to it and undoubtedly wasted much time in futile attempts to solve it, but the modern and accomplished mathematician knows the limitations of his subject too well to waste valuable time in trying to do the impossible. The problem is as follows: "Given an angle, to construct an angle having one-third its magnitude, using nothing beyond Euclid's elements."

In his elements Euclid employs only straight lines and circles, and he assumes the power to draw a straight line between any two given points, and to draw a circle with a given radius and having any given point as a center. This then is the problem: and any process or method which goes outside these elements or brings in other means than those laid down, does not solve the problem. Thus, one gentleman, forgetting or ignoring the conditions, employs a string, or the properties of a string in his solution, and as a consequence the so-called "solution" is worthless, although he prided himself very much upon having obtained it.

A few years ago the writer was asked to pronounce upon the merits of the attempt where the solver had assumed the authority to draw a certain line to assist in the solution, and had laid it down as an axiom that this line could be drawn. The solution then became simple enough, as he had, in fact, "assumed" himself out of the difficulty. But if he had tried to draw the line by means of Euclid's elements, he would very soon have discovered that the drawing of this line, instead of being axiomatic, was a problem of the same order of difficulty as the original one. Many other attempts have come under the notice of the writer, but in every case any apparent solution obtained was due to a misunderstanding of the problem, or a misconception of the conditions by which it is surrounded. And it may be here pointed out definitely, that any departure from Euclid's elements in the attempt at solution vitiates the whole problem; and that if a person is allowed to assume the properties of the hyperbola, or of some other particular curve, the trisection of an angle becomes simple enough. The writer does not, therefore, propose to make any attempt at *solving the problem*, but rather

to show that it is insoluble. **Also, this article is not written for the accomplished mathematician, but for such as think that they have the ability to solve the problems presented.**

To trisect any given magnitude is to divide the magnitude into three equal parts such that the sum of the three shall be equal to the whole magnitude. With such a magnitude as a straight line this is easy enough. But the angle belongs to a class known as *periodic*, in which after a certain increase the function returns to its original value. These functions have the property that there are exactly two ways of dividing them into two equal parts; exactly three ways of dividing them into three equal parts, and generally exactly n ways of dividing them into n equal parts. And from the point of view of analysis every division is of equal importance, so that any analytic statement which gives any one division must of necessity give all. Hence, any statement which gives one of the forms of the trisection of an angle must give all three forms. And every attempt to trisect an angle by means of analysis leads to the solution of a cubic equation, i. e., to an equation having three roots, or three values for the unknown quantity, usually denoted by x.

Now, it is well known that by the intersection of two straight lines we can determine but one point, and that by the intersection of a line and a circle or of one circle by another we can determine only two points, and no more. But for the solution of the problem we must have some process which will logically, and under specified conditions, determine three points. But the line and the circle, the only figures permitted in Euclid's elements, cannot do this; so that it is impossible to trisect the angle by means of Euclid's elements.

As has been said, every attempt to trisect an angle by means of analysis leads to a cubic equation, and the relation between the solution of a cubic equation and the trisection of an angle is so intimate that the best method of approximating to the values of the roots of a numerical cubic equation is through the trisection of a proper angle by means of the trigonometric functions. It unfortunately happens that the general solution of the cubic, even when the roots are known to be all real, leads to an expression involving imaginaries, and so far no means of overcoming this difficulty have been discovered, if indeed they exist. And here is a field of investigation for the so-called angle trisectors, the search after a solution of the cubic in rational terms.

The ancients invented various curves for the geometrical trisection of an angle, such as the curve known as the *trisectrix*, the *spiral of Archimedes*, etc., but the simplest curve for this purpose is the hyperbola. It is evident that the trisection of a circular arc is in fact the trisection of the angle which it subtends at the center. Let EF be the chord of the arc EBF. Trisect EF at O and A, and through the midpoint of OA draw DB perpendicular to EF. These things can be done by Euclid's elements. Through A as vertex and F as focus draw a hyperbola with eccentricity 2, to cut the circular arc in P. Then P trisects the arc EBF; that is, FP is one-third of the whole arc. But this hyperbola cannot be drawn by any application of Euclid's elements.

From the nature of the hyperbola, FP is the same multiple of PQ, drawn parallel to FE, as FA is of AD. But $FA = 2AD$, and therefore $FP = 2PQ$. From which it is readily seen that FP is one-third of the whole arc. As we have no practical means of drawing a hyperbola, this solution is speculative and theoretical rather than practical, but it is accurate, if we assume the property of the curve.

All this may be readily understood by any one having an elementary knowledge of conics, but it is evident that this, and all other methods of trisecting an angle, transcend the capabilities of Euclid's elements. So we infer that *the problem* as handed down to us from ancient times *is not soluble*.

The problem of the duplication of the cube is: Given a cube to find the edge of a second cube such that the volume of the second cube may be exactly double that of the first. Now we know that if the edge of the cube is 1 its volume is 1; if the edge is 2, the volume is 8, or 2^3; if the edge is 3 the volume is 27, or 3^3, etc.; or generally, if the edge is a the volume is a^3. If then we say that the edge of the cubic altar of Apollo was a, and the edge of the new altar was x, we must have $x^3 = 2a^3$, and therefore we must extract a cube root, which is equivalent to solving a cubic equation, in order to find the quantity x. Thus one value of x is $a\sqrt[3]{2}$. But x must have three values, just as in the case of the trisection of an angle. It is quite true that in the case of the trisection of an angle, the resulting cubic equation has three real roots, while in that of the duplication of the cube there is only one real root and two imaginary ones. But analysis does not take any note of this difference, all of the roots, whether real or imaginary, being of equal analytical importance; the fact of its being a cubic equation involves in itself the existence of three roots.

We see then that the problem of the duplication of the cube cannot be solved by the use of the line and circle alone, and these are the tools by which the ancients tried to solve it. The solution is somewhat easily effected if one is allowed the use of the conic sections, or if any of several other curves.

The third of these ancient and classical problems, the quadrature of the circle, or as it is generally termed, the "squaring of the circle," is of a somewhat different nature from the other two. The problem may be defined in several ways, namely, to draw a straight line equal in length to the circumference of a circle; or, to find the side of a square whose area shall be equal to that of a given circle, etc. But, better still, if we denote the ratio of the length of the circumference of a circle to that of its diameter by the Greek letter π, as is usually done, the problem becomes—"to find the exact value of π." This appears to be the most attractive of the three ancient problems, judging by the number of people who give their attention to this particular one.

A quantity which cannot be accurately expressed by any array of arithmetical figures either as a vulgar fraction or a decimal, is said to be incommensurable. Thus the square root of 2, of 3, of 5, and of every non-square number is incommensurable, and we cannot possibly write down in the symbols of arithmetic a number such that its square will give exactly 2, or 3, or 5, etc., although we can come as near to it as we please by carrying the sequence of figures far enough. So also the cube root of every non-cube number is an incommensurable.

Now it was proved by Lambert in 1761 that π represents a number that is incommensurable. In 1803 the great French geometor, Legendre, showed that the square of the number denoted by π is also incommensurable, so that π cannot represent the square root of any commensurable or expressible number. Moreover, in 1882 Lindermann proved that π cannot be the root of a rational algebraic equation, so that π is not any root of any commensurable quantity.

Of course, it is well known that geometrical construction can give lines that are incommensurable with certain given lines taken as a unit. Thus if a denotes a given line, it is comparatively easy to construct graphically $a\sqrt{2}$, $a\sqrt{3}$, etc., but it is not possible, as pointed out before, to construct $a\sqrt[3]{2}$, $a\sqrt[3]{3}$, etc. But π is not any root, and therefore could not be constructed even if it were possible to construct $a\sqrt[2]{2}$, etc.

These facts, which appear as consequences of the most rigid analysis, should be sufficient to settle the case for the "circle squarers;" but it is doubtful how far they will have any effect. For with the perverseness of human nature and the general ignorance of higher mathematical ideas, every newcomer into the field will be inclined to think he may possibly succeed where so many of his predecessors have failed. But it is possible that some of these gentlemen may suppose that they have reached an approximation to the true value.

Well, this is all any one can do at the best But however creditable it may be to the tyro in mathematics to arrive at even an approximation to the value of π, yet no general credit attaches to such results, as approximate values have been known for some thousands of years.

The ancient Egyptians, or many of them, took 256/81 or 3.1605 for the value of π, while Archimedes, the ancient Greek, proved that the true value of π lies between 220/70 and 223/71, that is between 3.1428 and 3.1408. In India about the year 530, Arya Bhata gave 62832/20000, or 3.1416 as the value of π, which is correct to 4 decimals; and during the 17th century the elder Metius, by a sort of happy guess work, arrived at the number 355/113, which is correct to five decimal places. Modern mathematicians have discovered a number of infinite series which taken alone, or in certain combinations, express, when summed to infinity, if such a thing were possible, the exact value of π. By taking the sum of a sufficient number of terms of such a series one may approximate to the value of π as nearly as he pleases. The simplest series of this kind is:

$$\tfrac{1}{4}\pi = 1 - \tfrac{1}{3} + \tfrac{1}{5} - \tfrac{1}{7} + \tfrac{1}{9} \ \ldots \text{ ad inf.},$$

but it is so slowly convergent that it would require the sum of some hundreds of terms to give a fairly close approximation.

The best combination of series for the purpose is known as Machin's formula, and is:

$$\begin{aligned}\tfrac{1}{4}\pi = 4 &\left\{ \tfrac{1}{5} + \tfrac{1}{3}\cdot\tfrac{1}{5^3} + \tfrac{1}{5}\cdot\tfrac{1}{5^5} + \tfrac{1}{7}\cdot\tfrac{1}{5^7} + \ldots \text{ ad inf.} \right\} \\ &- \left\{ \tfrac{1}{239} + \tfrac{1}{3}\cdot\tfrac{1}{239^3} + \tfrac{1}{5}\cdot\tfrac{1}{239^5} + \tfrac{1}{7}\cdot\tfrac{1}{239^7} + \ldots \text{ ad inf.} \right\}\end{aligned}$$

By taking 10 terms of the first series and 2 of the second we obtain:

3.1415926535898 . . .

true to the last figure, for a close approximation to the value of π. This quantity is so close to the exact value of π that in calculating the circumference of the earth from its diameter the error would be less than the ten-thousandth part of an inch. Many other series have been discovered which in the totality of their summation give the value of π, and this value cannot be expressed in any way except as the sum of an infinite series. And in conclusion it may be said that the approximation to the value of π has been carried to the unprecedented extent of 500 decimal places. What folly it is then for people to waste time, and in many cases mathematical ability, upon attempts to do that which is shown to be an impossibility. But this is done not only in the case of purely mathematical problems, but in that of some physical ones also.

The Physiological Effects of the Mercury Arc

Its Influence Upon the Eye

There has been more or less dispute as to whether the light of the mercury vapor arc produces any observable effect on the vision of those habitually using it. It is probable that where belief has existed as to the injurious nature of the light, this has been due to prejudice against its peculiar quality rather than to any actual observation of ill effect. In a case where about four years ago the mercury vapor tube was adopted by a large printing office the men employed were at first inclined to criticise the light, but after a short experience all favored it strongly, some even going so far as to claim for it a curative effect on weak eyes. The results of an investigation carried out by Dr. W. H. Williams, and published in the *Electrical World*, from which this resumé is taken, confirm this experience of a large number of men extending over four years, though he observed a certain amount of temporary color fatigue, which, however, is inevitable in the regular use of any strongly colored illuminant. As regards other effects on vision in which his results are completely negative, the clinical records for this group of twenty-eight persons show certainly quite as good conditions as would be expected in any other group of similar size working much by artificial light. There is always opportunity for eye strain owing to glare from misplaced lamps in the use of artificial light, and probably the mercury arc is not exempt from this difficulty. Certainly if it were at all more likely to produce eye strain than other lamps, some evidence of the fact should have been observable in the careful examination of this number of cases, whereas no evidence of it appears.

The color fatigue observed was of a particularly interesting character from a theoretical standpoint, although practically of small account from its evidently temporary character. The strongest lines in the spectrum of the mercury arc, to which at least nine-tenths of the visible light is due, lie close to the point at which the red and green sensations, as given in the curves of Koenig and others, overlap with nearly equal ordinates, and hence both these sensations are subject to fatigue in somewhat nearly equal degree. It therefore appeared, in general, in Dr. Williams's color sense tests, that there was comparatively little confusion of red and green. On the other hand, the fatigue of the green sensation showed rather plainly at the contact of the blue and green owing to the greater fatigue of the latter sensation. Even this did not appear in the group of draftsmen investigated who used the light only a portion of the time, and it seemed to disappear in the other cases after a few hours' rest. This is quite in accordance with the results of Burch, who was able to produce all kinds of temporary color fatigue by suitable exposure to colored light, which while temporarily complete, disappeared after the eye had opportunity for rest. It would be interesting to follow out the matter of color fatigue in using other artificial illuminants. The yellow flame arc might be expected to give results not very different from those here recorded, while in the case of ordinary flame illuminants and incandescent lamps some red-green fatigue

should still be evident owing to the predominence of these colors. As regards other ophthalmological matters, Dr. Williams's results are about what might be expected. At all events, it is gratifying to have these thoroughly negative results recorded, and we are inclined to the opinion that similarly negative results will be found in general for workers under artificial light, assuming that it is intelligently installed. It is improper use, rather than much use, of artificial light which is chargeable with eye strain, and when eye strain exists it can generally be remedied by intelligent rearrangement of the illuminants.

The Transplantation of Members and Organs

Constructive Surgery

THE idea of removing a diseased member and replacing it by a sound one is by no means new. An old painting in Florence represents a miraculous operation of this kind in which the sacristan of the Church of St. Como and St. Damien is the patient, the saints are the surgeons, and the leg substituted for the sacristan's cancerous limb is taken, without regard to color, from a dead Moor. The Golden Legend relates that the sacristan dreamed of this operation and awoke to find it accomplished. This story is quoted by the French surgeon, Alexis Carrel, now one of the directors of the Rockefeller Institute for Medical Research in New York, and to Carrel belongs the honor of converting the legend into fact by making vascular surgery easy and sure. In 1902 Carrel devised a new method of direct suture connecting three base points, which has supplanted all other methods and which makes it possible to transplant entire members and organs with success. The operation is performed as follows:

The ends of the blood vessels to be joined are laid bare and closed temporarily by flexible pincers to stop the flow of blood. With very fine straight or curved needles and fine silk or linen thread, three points distributed at equal distances around the periphery of each vessel are connected to corresponding points of the other vessel. By traction exerted on these joined points, a triangular form (Fig. 1) is given to the open ends of the blood vessels and the edges are sewn together, by the method known as overhanding, along the sides of the triangle. The pincers are then removed, the joined blood vessels are replaced and the wound is closed. The most perfect asepsis must be observed and the inner coats of the vessels must not be lacerated; otherwise a blood clot, which will close the passage, will be formed. For this reason the thread and needles are sterilized in vaseline, which is an anticoagulant.

This method has been adopted with success by several other American and European physiologists. The consequences of this discovery has been far-reaching. It has been found possible to anastomose, or join, arteries with arteries, veins with veins, and even veins with arteries. Carrel and Guthrie have connected the carotid artery with the jugular vein. The animals operated upon appeared to be in perfect health seven months after the operation. These physiologists have connected the peripheral end of the right renal vein and the left renal artery, causing the venous blood of the right kidney to flow into the artery of the left kidney and return to the *vena cava*, after having traversed the left kidney and the left renal vein. Tuffier has exhibited a dog four weeks after an operation in which the central end of the femoral artery was joined to the peripheral end of the femoral vein, and conversely.

Thus it was shown that anastomosis of arteries and

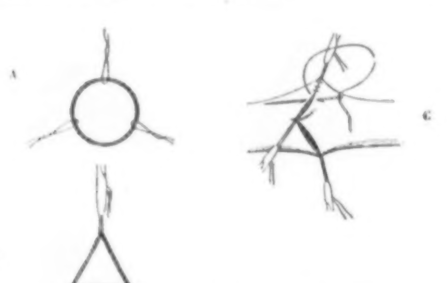


Fig. 1.—Four Stages of Carrel's Operation for Joining Blood-vessels.

veins is possible and that the passage remains open. The next step was to substitute a segment of one blood vessel for one of another. This is necessarily the first stage in the transplantation of organs.

The transplantation or grafting of tissues had already been attempted frequently both in men and in animals. Progress, however, was slow, for it was soon observed that the transplanted parts quickly became surrounded by fibrous tissue and, being thus isolated, gradually wasted away, owing to an insufficient supply of blood. The discovery of a method of joining large blood vessels gave a new encouragement to experimenters in transplantation. If large blood vessels can be properly joined, the transplanted organ which they supply will preserve its vitality. Thus transplantation *en masse* was substituted for the former method of simple juxtaposition.

These transplantations are classed as autoplastic when the transplanted part is taken from the same individual, homoplastic when it is taken from another individual of the same species, and heteroplastic when it is taken from a different species. In 1908 Carrel removed both kidneys from a dog and placed them in Locke's saline solution. He then replaced one of the kidneys and sutured the renal artery, renal vein and ureter. The circulation was re-established about 50 minutes after the extirpation. In order to shorten the operation, only one kidney was replaced, and this transplanted kidney was required to perform the functions of both. For a time the animal remained in excellent health and its urine contained no albumen. After about 45 days the presence of pus was detected, and the animal died of ascending infection two months after the operation.

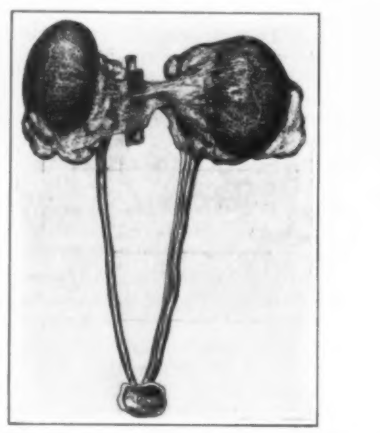


Fig. 2.—A Cat's Kidneys With Their Connections, Removed for Transplantation to Another Cat.

Carrel and Guthrie also succeeded in transplanting the kidneys of a cat to another cat. The two kidneys were removed together with their blood vessels, part of the aorta and *vena cava* and the entire ureters (Fig. 2). The whole mass was transplanted to the other animal on which a similar operation had been performed (Fig. 3). The circulation was re-established by circular suture of the aorta and *vena cava*. With the ureter was transplanted a small portion of the wall of the bladder, which was sutured to a corresponding orifice made in the bladder of the other animal. Fourteen animals were thus treated. Most of them lived one or two weeks; one died on the 17th day with all its arteries calcified; another died on the 30th day. One animal lived 35 days, during which its urine remained clear and almost normal, containing only one-quarter per cent of albumen.

In February, 1908, Carrel extirpated the left kidney of a dog. The kidney was washed and placed in Locke's solution and in a few minutes replaced in the abdominal cavity. The blood vessels and ureters were sutured, and the animal soon recovered. Two weeks later the right kidney was extirpated. No accident resulted and no albumen appeared in the urine. In April, 1909, the animal normally gave birth to a litter of eleven.

Vascular anastomosis has produced, in the hands of Carrel and Guthrie, equally marvelous results in the transplantation of members. In 1908 Delbet exhibited the hind leg of a dog, which at first sight appeared quite normal; it was really, however, the result of homoplastic transplantation, the thigh having belonged to one animal and the lower leg to another. The two portions were grafted together by anastomosing the blood vessels and connecting the nerves, muscles and skin by suture. The dog died 22 days after the operation, in the course of an epidemic of bronchial pneumonia.

Hetroplastic transplantation is less successful. Carrel succeeded in 1907 in transplanting part of the carotid of a dog to the abdominal aorta of an old cat which, 17 months afterward, was in perfect health and showed absolutely normal femoral pulse. Carrel observed, however, that transplantation from one species to another produces changes in the structure of the transplanted part, in which the elastic fibers and subsequently the muscular fibers of the blood vessels waste away.

These new surgical methods have been applied to human beings. In 1907 Delbet endeavored to restore the circulation in a man 74 years old, suffering from an aneurism of the femoral artery, by substituting a segment of the femoral artery taken from a limb which was about to be amputated, in another ward. Unfortunately the old man's arteries were too hard and calcareous, and the sutures would not hold.

Even the transplantation of organs has been attempted in the human species. In 1906 Jaboulay transplanted a pig's kidney to the bend of the elbow of each of two women suffering from incurable kidney disease. The renal vein was sutured to the vein of the lower arm and the renal artery to the femoral artery. In one patient the daily secretion of urine was increased from one pint to three pints by the operation. Unfortunately, the sutures were made by the old defective methods and the anastomosed vessels closed.

The replacement of a segment of an artery by one of a vein might render great services. For example, an aneurism of the carotid could be removed and replaced by a segment of the femoral vein, or a humeral aneurism by a segment of the saphene vein taken from the same subject. Many such attempts had been made, but without success.

In 1907 Carrel transplanted part of the external jugular vein of a dog to the carotid. The circulation was perfectly re-established. In February, 1909, the dog was killed in a battle with its companions. The caliber of the transplanted vein was found slightly dilated and its walls thickened, showing that the vein had adapted itself to its new function, and the suture was almost invisible (Fig. 4). Lexer substituted about three inches of the saphene vein of the thigh of a human subject to the axillary artery. The circulation was perfectly re-established.

The substitution of a segment of one blood vessel for one of another is not the only vascular transplantation that has been attempted. A strip or a segment of a blood vessel can be replaced by any membrane of similar nature like the peritoneum, as Carrel has successfully demonstrated (Fig. 5). When only part of the wall of a blood vessel is diseased, it can be replaced by a simple patch taken from another blood vessel of the peritoneum. This is the "method of patching" (Fig. 5).

If, together with the transplanted blood vessels, the organ which they nourish is also transplanted to an-

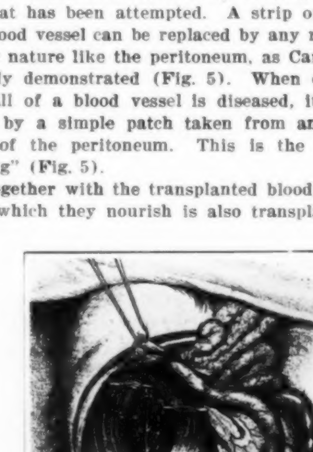


Fig. 3.—The Second Cat, with Its Kidneys Removed, Ready for the Reception of the Kidneys of the First Cat.

other animal of the same species, this organ will continue to perform its functions. Carrel and others have made many transplantations of kidneys, thyroid glands and spleens by this method.

Dr. Burmier, who gives this description of the new methods in *La Nature*, adds that, although the method of vascular grafting represents a great advance, considerable success has been obtained by the older method of grafting by juxtaposition. In this way large segments of arm and leg bones of persons suffering with sarcoma have been replaced by pieces of healthy

bone taken from the patients or from freshly amputated limbs. The persistence of the junction of the bones has been shown by radiography. Lexer transplanted the entire knee joint in a child.

Both methods of transplantation are hampered by the great difficulty of obtaining material. In France human material can be obtained only from amputations, as the law forbids corpses, no matter how badly mutilated, to be touched until 24 hours after death. It is an unusual coincidence to find a fresh corpse or a recently amputated limb at the very moment when the material is wanted. Hence a method of preserving the material is of great importance. In 1908 Prof. Delbet expressed the hope of seeing in every surgical hospital a cabinet filled with carefully preserved arteries, veins, internal organs, joints, legs and arms, from which the surgeons could select the suitable material for the use of their patients.

Fig. 4.—Part of a Dog's Jugular Vein Transplanted to the Carotid Artery of the Same Dog—The Suture Is Marked by the Cross.

This hope is already partially realized, at least for blood vessels. Carrel removes blood vessels from living animals, or those on the point of death, with rigorous asepsis, washes them in Locke's solution and places them in sterilized glass tubes, which are sealed and kept in cold storage at a temperature just above freezing. The structure of these blood vessels does not appreciably change in six or even ten months. When the specimen is wanted for transplantation the glass tube is broken and immersed in Locke's solution at room temperature. The specimen is washed and placed in hot vaseline, which is carefully expressed before grafting. The grafted part, which has become colorless, immediately assumes the appearance of the living artery. Carrel has seen the blood vessels supplying a carotid, which had been kept eleven months in cold storage, instantaneously fill with blood.

In November, 1906, Carrel transplanted a segment of a dog's carotid, which had been kept 20 days, to the aorta of a cat, which in May, 1909, was in perfect health, with normal femoral pulse. With equal success a segment of an artery from an amputated human thigh, which had been kept 24 days in cold storage, was transplanted to the aorta of a dog.

In the transplantation of bones, Kausch has even succeeded in using a dead bone. Kausch removed four inches of the upper part of the tibia of a 19-year-old girl suffering from sarcoma, and replaced it by a portion of a tibia obtained some days before from an amputation. This fragment had been deprived of its periosteum and bony marrow, treated with ether to remove grease, and thoroughly boiled. It was fastened to the lower end of the patient's femur and the upper end of the shortened tibia with ivory pegs. The patient recovered from the operation, but nine months afterward the tumor reappeared and necessitated amputation of the thigh. It was then found that the transplanted dead bone was perfectly joined with the femur and tibia and was surrounded by periosteum.

These results are interesting and encouraging. They show that a new era is beginning in which surgery, hitherto almost entirely destructive, will tend to become perservative and reconstructive.—Translated from *La Nature* for the Scientific American.

Fig. 5.—A Piece of Peritoneum Grafted on an Aorta—The Suture Indicated by Crosses.

The Action of Radium Upon the Embryo

Researches That Shed New Light Upon Fertilization

The radiations of radium promise to furnish a valuable instrument of research in the difficult field of reproduction and heredity. This is the conclusion which Prof. Oscar Hertwig draws from his experiments on the influence of radium rays on the development of the eggs of frogs and sea-urchins. The experiments with frogs' eggs are described in a recent article in *Die Umschau*, of which the following is a summary.

No change that can be detected with the microscope is produced immediately by the action of the rays upon the eggs, which, if fertilized, begin to develop normally. The development exhibits, sooner or later, however, characteristic abnormalities, which vary in degree according to the duration of exposure to the rays, and differ in kind according as the rays are applied to the egg before or after fertilization or to the spermatozoa employed for fertilization.

In one series of experiments designated as series A the rays were applied to fertilized eggs, in the first or second stage of cell-division, during periods which varied from 5 minutes to more than 3 hours. In series *B* the rays were applied in a similar manner to spermatozoa, which were then employed to fertilize eggs that had not been exposed to the influence of radium. In series *C* unfertilized eggs were exposed to radium rays and were then fertilized with spermatozoa that had not been so exposed.

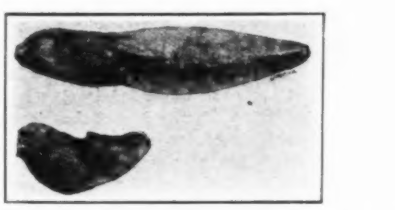


Fig. 1.—Normal and Series B Embryos, 10 Days Old.

In the eggs of series *A* development stopped and the embryos perished at the morula or mulberry stage. In series *B* the development progressed much further and was not arrested until the sixth or seventh day after fertilization, or even later. The head, tail and spinal cord were partly developed, but in an abnormal manner, and some of the cells showed disorganized nuclei. The embryos could be instantly distinguished from normally developed embryos of the same age by their smaller size, monstrous form (dropsical abdomen and atrophied tail), and bloodless appearance.

These experiments show that the effect of radium rays can be transmitted to the embryo by a spermatozoon which has been exposed to their influence, but that the disturbance thus produced is much smaller than that which results from an equally long exposure of the fertilized eggs to radium rays of the same intensity. This result is in perfect harmony with the conception of the nature of fertilization which is suggested by microscopical research, and according to this view, the fertilized egg is a dual organism, resulting from the coalescence of two cells, one of which is furnished by each parent. As only one of these components, the sperm-cell, was exposed to the radiations in series *B*, while both components were so exposed in series *A*, it is not surprising that the effect was greater in the latter than in the former case.

Fig. 2.—Normal and Series B Embryos, 12 Days Old.

It is important to determine which part of the sperm-cell, or the ovum-cell, is affected chiefly, or solely by the rays of radium. Microscopic examination of the abnormal embryos of series *A* and *B* points to the nucleus as the seat of action. The nuclei of cells of various organs exhibit such abnormalities as irregular arrangement of parts, escape of particles of chromatin into the surrounding protoplasm, and a transformation of the normal nucleus into a ball of chromatin, as is observed in other cases of cell degeneration.

The view that the rays of radium act principally on the nucleus is made still more probable by the following considerations. The spermatozoon compares with the egg, in size, as a grain of wheat compares with the contents of a sack holding several bushels. Yet the influence of the spermatozoon which has been exposed to radium rays is sufficient to affect every part of the embryo, to an advanced stage of development, and ultimately to cause its death.

This astonishing result becomes intelligible when we remember that one ingredient is contained in equal quantities in the tiny spermatozoon and the comparatively huge egg. This ingredient is the substance of the nucleus. Hence the nucleus of the fertilized egg contains equal parts of male and female nucleus substance. The increase of the former by cell-division is not prevented by exposure to radium rays. Hence, in the experiments of series *B*, the nucleus of each new cell of the developing embryo, like the nucleus of the original cell, contains equal parts of male nucleus substance, affected by radium, and of female nucleus substance, not so affected. In this way the effect of the radium rays is transmitted to every cell of the organism through successive stages of development.

The process is analogous to the infection of an animal by a single bacterium, which multiplies within the body until the cumulative action of its multitudinous progeny makes life impossible.

The experiments of series *C* furnish a crucial test of the correctness of these views. In this series the radium rays were applied to the whole mass of the unfertilized egg, which was then fertilized with a normal or unexposed spermatozoon of comparatively infinitesimal size. If the whole mass of the egg is affected by the rays we should expect the eggs of series *C* to behave like those of series *A*, and die at a very early stage, as the dilution of the exposed matter with so small a proportion of unexposed matter would not be expected to produce any perceptible effect. In fact, however, the embryos of series *C* in general, lived as long as those of series *B* and developed in the same manner (Fig. 3). Hence the final result is the same, whether the spermatozoon alone or the unfertilized egg alone is exposed to the action of radium rays. In other words, the development of an egg, which has been exposed to radium rays before fertilization, is as powerfully promoted by a normal spermatozoon as the development of a normal egg is hindered by a spermatozoon affected by radium radiation.

From all of these facts it appears certain that the action of radium is exerted through the nucleus. This is a strong argument in favor of the theory that the nuclei of the sperm-cell and the ovum-cell are the vehicles by which hereditary characters are transmitted from parents to offspring.

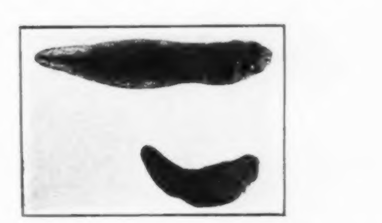


Fig. 3.—Normal and Series C. Embryos, 10 Days Old.

Properly devised experiments with radium radiations may aid in the solution of various problems in heredity.

Tessie du Motay's Blue.—Dissolve 10 parts tungstate of soda, 8 parts tin-salts, 5 parts yellow prussiate of potash and 1 part chloride of iron in suitable quantities of water. Mix the solutions, wash the resulting precipitate and expose it, in thin layers, to the light, the blue color will develop in the course of a few days. According to the discoverer's opinion, this color consists of a combination of oxide of tungsten with a double cyanide of iron and tin. In its physical properties, this color resembles a beautiful Berlin blue, but differs from this in its greater light resisting faculty—also however, by much higher cost of production.

The Fate of the Planets*

Svante Arrhenius

According to the Laplace theory, accepted by most astronomers, all planets were originally in a gaseous form, just as at the present time is the sun and probably also the greater major planets, Jupiter, Saturn, Uranus and Neptune, judging from their low density which is very near that of the Sun. We are unable to learn more of these planets owing to the interference of heavy layers of clouds. But we may assume the existence of an atmosphere on these gaseous bodies. The density of these gases increases as we approach toward the interior of the planets, till it becomes so great, that the gases cannot be compressed any further, when the density increases but slightly, and the gas behaves like a solid. The transition in density between the various layers in the planets is only a gradual one, whereas in planets having a real atmosphere the density changes in sudden leaps. If other planets are made of the same material as our Earth, namely, of heavy metal, their oxides, silicates, carbonates, hydrates, and perhaps the hydrosulphides of the lighter metals, including aluminium and hydrogen, then we must necessarily demand a solid crust, if we are to assume the existence of life on them. For the melting point of all these substances is so high (at least over 1,000 deg.) that animate things could not exist in their presence, even far below their solidifying point. Life is bound up with the presence of very complex, and therefore very unstable carbon compounds, which are destroyed at a temperature much lower than 1,000 degrees. These carbon compounds are unstable even below the boiling point of water, the albuminoids passing over into the liquid state at 55 to 60 degs. At any rate we must assume that they cannot exist above the critical temperature of water, at 365 deg. C. We have here a second necessary condition for life, namely, the condensation of water, or in other words, the conditions at which bodies of water will form. But since an open body of water, without a water vapor of at least 4.6 mm. pressure is not stable, the presence of large areas of water presupposes the existence of a real atmosphere. Oxygen is another necessity for life, and since oxygen cannot exist without the added presence of a solid crust, we can briefly express all the conditions necessary for life by the one item: the presence of an atmosphere containing oxygen.

Only those planets which have a real atmosphere can harbor living beings, and for this reason the question of the atmosphere on the planets is of prime interest. As a matter of fact the planets inclosed in an atmospheric envelope are very few in number. In our solar system, whose planets are the only ones known to us to any extent, we have only the four minor planets, Mercury, Venus, Earth and Mars, who may fulfill this requirement. It is probable, however, that the smaller planets, moving between Mars and Jupiter contain a solid crust. Of all these, there are only three that are provided with a real atmosphere, Earth, Venus and Mars. Mercury is like the Moon, and has almost the same power to reflect light. This power of reflecting light is called "Albedo," and Mercury and the Moon have only 0.14 and 0.13, respectively, while Mars has 0.22 and Venus 0.76. The Moon has no atmosphere, and the same is probably true of Mercury, while that of Venus seems to be similar to the atmosphere of the Earth. The albedo of the Earth is, however, far below that of Venus. One of the questions often asked is, why these planets do not reflect as much light as a cloud, since everything on them seems to be enveloped in clouds. The answer is that these planets, as also Uranus and Neptune, contain powerful absorbing gases in their atmosphere, which influence the reflecting power of the clouds.

The absence of an atmosphere on the Moon is ascribed to the excessive speed of the hydrogen molecules, which move so fast that the moon cannot attract any of them and hold them. The same is also true for the other light gases. The less the force of gravitational attraction is on these heavenly spheres, the fewer gases will be found in their vicinity. It may, therefore, be supposed that the inferior planets, have no atmosphere at all.

Gravitation on Mercury is not quite one and one-half times as large as that on the moon, and as a result Mercury is probably as powerless as the moon to attract gases. But another factor enters here. Mercury always turns the same face toward the Sun. Consequently the dark side, turned toward space has a temperature of at most 50 degrees above the absolute zero, at which temperature all gases, except helium and hydrogen condense and form gigantic masses of ice. But since these two gases are so light that they have disappeared ages ago, there are probably no gases at all on this planet. The case of the Moon is analogous. Venus, although always turning the same face toward the Sun, has a dense atmosphere. Helium and hydrogen are not found on this planet, since these two gases have a tendency to disappear even from our air, and still more from a planet whose gravitational force is one-fifth less than that of the Earth. Of Mars we know by observation that the poles are covered with snow, a fact which can only point to the presence of an atmosphere. Traces of fogs and clouds have also been noticed on that planet. This is about the limit of our knowledge of atmospheres in our solar system. Doubtless there are other planets with atmospheres, although we do not know of such. Many of them are probably so large that we may assume them to be entirely composed of gases without any traces of an atmosphere and with no animate life on their surface.

We know very little of the chemical composition of the atmosphere of our neighboring planets. Mars has probably some water vapor in his atmosphere, as shown by the presence of snow near the poles. Venus, whose atmosphere is much like that of the Earth, has doubtless also water vapor like Mars, only in greater quantities on account of the higher temperature. Oxygen may be present on Mars, though this is only a conjecture based on the assumption that the atmospheres of the planets are similar to that of the Earth.

If we study the development of the Earth's atmosphere, we find that the oxygen in the air is about equivalent to the amount of carbon found in the Earth's crust. This would lead to the conclusion that the oxygen of the air, like fossil coal or carbon had its source in carbon dioxide, from which it separated, and that originally there was no oxygen in the Earth's atmosphere. There was a large quantity of hydrogen, a little helium, nitrogen, cyanogen, some carbohydrates, carbon monoxide, and a little oxygen. These gases were set free from the nebular ring which enveloped the sun, and had doubtless the same chemical composition as the exterior layers of that body. When cooling off, the oxygen combined with hydrogen or carbon monoxide, and since there was an excess of hydrogen, much of this latter gas remained after the oxygen had disappeared in the course of the chemical reaction.

We arrive at the same conclusion in another way. Meteorites and comets, whose interior is similar to that of our Earth from the standpoint of chemical composition, contain hydrocarbons, carbon monoxide, cyanogen and much iron, all of them compounds that combine readily with oxygen. In other words, the bulk of the Earth, like meteorites, comets and the sun, has strongly reducing properties. If there was any oxygen present at the original high temperature as a result of the dissociation processes, it must have combined very soon with the most powerful reducing agents which were components of the gaseous mass of the Earth during the cooling process. In spite of this we find a good deal of oxygen in the air, which is not the work of the plant life, as claimed by some authorities, for it is very unlikely that there was any plant life on the planets in their initial stages owing to the absence of oxygen. We must assume that oxygen developed under the influence of sunlight on carbon dioxide, and that the plants took up this work of extracting oxygen from the air only after there was quite a supply of free oxygen in the atmosphere.

The oxygen was probably not liberated until the Earth had formed a solid crust. Before this, any liberated oxygen would be attracted by the strongly reducing agents in the Earth's interior and be absorbed. It is supposed that at the high temperatures prevalent before the silicates formed into a solid crust, water had stronger acid qualities than silicic acid. At that time the neutral solvent in the exterior layers of the Earth was silicic acid and not water. But as the crust solidified and the masses of silicates below cooled, the silicic acid surpassed the water in acid qualities, and the hydrates along with the strong excess of silicic acid in the upper, light, and very acid silicates were transformed into water and silicates. The upper strata of silicates in the Earth's magma gave off water vapor and carbon dioxide to the gaseous envelope of the Earth. The cooling and condensing process went on continually, the crust became denser, and there resulted the present atmosphere of our Earth. Nitrogen was probably present in the early stages of atmospheric development either in the form of free nitrogen or in combination as cyanogen. Later some of the cyanogen decomposed in the cooler atmosphere and gave off carbon and free nitrogen. Hydrogen sulphide and hydrochloric acid combined with the silicates, that had dissolved in the warm water, and condensed on the Earth's surface, the former making sulphuric acid by combining with the nascent oxygen. The water vapor condensed and formed oceans, the carbon dioxide changed to carbon and oxygen. As the cooling process advanced, great portions of the Earth's crust collapsed, leaving long straight fissures and cracks, which became the seats of volcanic eruptions and earthquakes. The thicker the crust becomes, the slower is the cooling of the Earth's interior, and at the same time the less is the supply of carbon dioxide and water, necessary conditions for organic life. These two are, however, consumed continually by plant life and atmospheric decay and changes. Finally the supply is less than the loss by atmospheric changes. Water and carbon dioxide gradually disappear from the face of the Earth. This decrease in carbon dioxide will lower the temperature of the air and the amount of water vapor in the atmosphere. Geologists are agreed that the parts of the world now occupied by deserts had a moist climate in the last glacial period. Since then those parts of the world have dried out more and more. This drying out process proceeds very slowly and will take millions of years to be noticeable, but it will eventually lead to the drying up of the seas. Conditions on the Earth will then be similar to those on Mars. Great expanses of desert will cover the major portion of the planet; mountains are razed by the continuous action of the desert sand, leaving only a chain of undulating ridges. The earth will be a desert waste, like the Sahara. The fissures in the crust have been filled with dessert sand, so that they are only shallow basins, in which lie dry shallow salt lakes, similar to the canals on Mars. The gases of the air will also disappear. Oxygen is used up in the course of atmospheric weathering, especially for the oxidation of iron compounds. Meteorites fall from the sky, and are at once oxidized. They cover the surface of the dying planet with an ochre-colored layer of iron oxide, as is now the case on Mars. Nitrogen is oxidized into nitrates by the electric discharges. The atmosphere and the hydrosphere of the planet will disappear, and the conditions on our Earth will be like those on Mars, approaching those on the Moon.

This, our satellite, had in the beginning, when separating from the Earth, a dense gaseous envelope, but lost it in the course of time. There were also canals as there are on Mars. But they were filled in by the sands, leaving only faint traces. The development of the Earth is similar to that of the Moon. On the whole we may say that a very slight cooling has taken place, corresponding to the gradual exhaustion of the sun's heat. This cooling process was very slow, however. The time when the earth first harbored animate beings, as found in pre-historic fossils, was marked by a surprisingly even temperature. The temperature was perhaps around 25 deg., followed by glacial ages with a very much lower temperature. Geoogists are now convinced that there were several glacial periods, separated by periods of luxurious, gigantic vegetation, with tremendous rainfalls and an even, moist climate of about 12 degrees, whereupon the plants and trees were imbedded in clay and lime and changed slowly into lignite and anthracite coal. Then there were periods of desert dryness. This long time of development has been estimated at two hundred to three hundred millions of years, characterized by relatively slight changes in temperature. Our earth at the present time is in a transition stage, in which no extreme prevails. The moist, warm climate, common in the past, is now confined to the tropics. If we increase this moisture and the cloud conditions considerably, we have the climate prevalent at the time when fossil coal was deposited, and as it is still found on Venus. Clouds cover everything; the degree of moisture is extreme, even during the rainless season; there are no great variations of temperature between the poles and the equator, between summer and winter, between day and night, heavy rains fall during the rainy season; such are conditions on Venus. The extreme moisture does not allow the air to become too hot in the lower layers; the air stagnates; the decrease of temperature with increasing altitudes is slight. The thick heavy clouds prevent great changes of heat, and cause a moist even climate to prevail over the whole planet. In the moderately warm parts, where decay is not too rapid, anthracite coal is formed in the swamps, and the animal and plant world grows to gigantic proportions owing to the abundance of food.

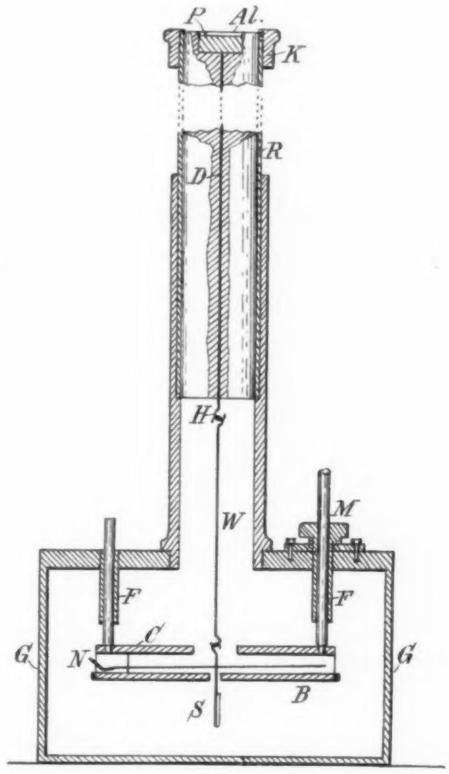
* Abstract of "Das Schicksal der Planeten" Akademische Verlagsgesellschaft, Leipsic.

On Venus the world is probably not advanced so far that fossils have already formed. But the soft remnants of lower organisms decay, disintegrate, and, if imbedded in clay and removed from the influence of oxygen, become lumps of coal, which may be later changed into graphite if exposed to enormous pressures in the planet's interior. The crust is still thin, and tremendous upheavals accompany its collapse. Perhaps near the polar caps, the world on Venus may be more advanced, the crust thicker, and the stability necessary for the formation of higher forms of life a little more pronounced. From there the higher culture of the future will gradually advance toward the equator.

If we take conditions in our earthly deserts as typical, we have a picture of the conditions on Mars, except that the Martian temperature is much lower than our own, being probably around —17 deg. C. The water was changed ages past to fossil ice, which is covered with very thin layers of loose earth, or, mixed with sand, forms a sort of rock, whose bonding medium is ice. The only water apparent on Mars, is that issuing out of the volcanic fissures, which, however, soon joins the rest of the ice and frozen ground waters. There are no rivers and oceans on Mars. The surface is modeled and shaped by the desert sand carried about by the windstorms. The resulting sandstorms take a reddish yellow or light yellow color, and have been observed, by the aid of powerful telescopes, speeding over the vast expanses on Mars. The Martian surface would long ago have been covered by a uniform ocean of sand, if the red hot interior of that planet were not subject to shrinking, accompanied by a sinking of the surface crust. Since Mars has advanced much further than the earth in its cooling process, these forces are much less powerful than here. They limit their action to a slow collapse of the crust, resulting in cracks, from which gases like carbon dioxide, hydrogen sulphide, water vapor and hydrochloric acid escape. These gases condense in the nearby soil, lixiviate the salts from the desert sand, and form new salt compounds, especially carbonates and chlorides. The former crystallize, and form with silicic acid and fine mud a relatively impervious soil, which prevents the rapid percolation of water. The chlorides remain dissolved and form saturated solutions, like our salt lakes. These solutions freeze only at very low temperatures (—21 degrees to 55 degrees) so that the salt lakes will remain in a liquid condition at least during the Martian summer. They freeze, however, in winter, the various layers of chlorides freezing in accordance with their freezing points. They show on Mars in dark blue spots.

As the surrounding desert sands try to cover these frozen lakes, they take on the reddish color, observed on that planet in winter. The year on Mars is twice as long as on the Earth, and the warmest section changes back and forth between the poles and the equator once every year. The white polar caps disappear rapidly, showing that they are composed of a thin layer of snow. The only spots that remain white, even in summer, are near the north pole, and a triangular island at the south pole, from which the white color never disappears. The atmosphere on Mars is almost cloudless, and is free from dust. The heat of the sun reaches the solid ground, and the poles of Mars with the surrounding country become the warmest parts of the planet, especially since the radiation of the sun's rays lasts twice as long as on Earth, and since no great bodies of water store up the heat energy. The snow near the poles is changed to water vapors, which is warmer than the surface of Mars, except at the polar caps. A real distillation of water vapor now begins in the thin Martian atmosphere, starting from the light pole, proceeding in the direction of the dark pole, the coldest spot on Mars. During this distillation period, the warm water vapors pass across the intervening regions, where the salt lakes absorb the vapors and take on a deep red, later a greenish hue. The south pole at this time shows as a large dark colored region, out of which rise several leather colored spots, probably islands. This expanse was probably at some former time a polar sea, covered millions of years since by a crust of ice one mile in thickness. In summer a few shallow salt water pools form on the surface of this sheet of ice, but in winter they contract again and form one solid body with the ice. Some of these moist spots form that network of canals observed on the planet. These salt pools extend along certain well defined lines, sometimes straight, sometimes crooked. The deepest depressions of these so-called canals lie along the cleavage lines of the Martian crust. Gases pour forth from these fissures and keep the salt solutions in a liquid state. Some of these canals converge toward some central point, and form lakes and oases. We need no unknown forces or properties of matter to understand conditions on Mars. Everything takes its course there, as it would on our Earth, if the temperature had remained at about 40 degrees below the present state for several geological ages. It is very likely that the earth will some day share the fate of Mars, after the sun shall have cooled to a greater degree.

If we wish to learn what fate awaits our Earth after the air has disappeared to a larger extent than is the case on Mars, we need only to look at our faithful satellite, the Moon. There the atmospheric pressure is only a few tenths of a millimeter. Originally, as the Earth and Moon separated, the latter had a portion of the Earth's atmosphere. But as the Earth contracted and the Moon receded to a greater distance, the air on the Moon disappeared gradually in the powerful radiation of the Sun's rays, at a temperature of 150 deg. C. on the hottest point of the planet. At the same time the water was converted into steam and disappeared, returning to Earth. The most conspicuous phenomena on the Moon are the seas and the volcanoes. The seas have a darker color than the environment and lie in deep hollows. They are obviously portions of the lunar surface which collapsed when the Moon cooled. The seas show traces of sunken volcanoes, the inner crater having been carried down into the vortex when the entire volcano collapsed. These craters are much larger than corresponding craters on Earth, owing to the greater force of subterranean explosions through the tremendously thick crust of the Moon's surface. The force of gravity is about one-sixth of that on Earth, with the



Electrometer Showing the Perpetual Discharging Effect of Radium.

result that a volcanic eruption can hurl six times as mighty masses of rocks as an earthly force. The magma of the Moon seems to have liberated its sluggish, acid, granite-like component parts at an earlier period, and retained the fusible basic masses for later eruptions. This is connected without doubt with the greater specific gravity of the basic lava. Of peculiar aspect are the long fissures radiating from the craters in straight lines. They are marked by no shadows, and lie, therefore, in the same plane as the surrounding country. These fissures perhaps ran at one time toward one central point, in which the larger crater lies, and were filled with light volcanic ashes at a time when the Moon still had a gaseous envelope. On the whole, we may say then that the Moon looks similar to Mars, except that all the air has disappeared from the former, and volcanic action has ceased, so that no gases are liberated to any large extent. The semi-lunar day and similar night cause an enormous change of temperature, about 150 degrees above and below zero on the lunar equator. The average temperature of the Moon is about that of the Earth on account of the similar average distance from the Sun. But there is no life on the Moon.

The results of our investigations show that the Earth's atmosphere has gone, and is still going through great changes. In view of the similarity in the chemical composition of the Earth and the other planets which have a solid crust, it is supposed that the planets' exterior layers in a molten state consisted of a magma corresponding to the silicate magmas of our Earth. The low specific gravity (Moon, —3.34; Mars, —4.03; Venus, —5.18) as compared with that of the Earth (5.53) shows that the Moon is composed entirely of silicates, Mars probably to a large extent of the same material; Venus, however, like the Earth, one-half of silicates and one-half of a metallic core. If we accept the opinion that the Moon was a result of an outgrowth on the Earth's mass, and then separated from the same, we must also accept the statement that the Moon consists mostly of the same material as the earth.

Summarizing the preceding points we obtain the following picture: As the magma cooled, a solid surface formed, followed by the development of an individual atmosphere. Gases issued from this interior, accompanied by water vapor and carbon dioxide, and rose into the highest layers of the atmosphere. The light of the sun exerted a photochemical action on this atmosphere, resulting in the formation of oxygen and carbon. The strongly reducing gases of the original atmosphere, like hydrogen, the hydrocarbons, etc., were oxidized by the oxygen, so that in the end, besides the oxygen, we had only chemically inactive or inert gases, like nitrogen, as the principal components of the atmosphere. The two gases necessary to life, besides oxygen, namely, carbon dioxide and water vapor, issued out of the cracks in the planet's crust and mixed with the atmosphere. Life began to develop under these favorable conditions. The earth at the present time is in this state, and probably also Venus, where the development, owing to the higher temperature (65 deg. C.) has not advanced as far as on Earth. Gradually the thickness of the crust will increase. The water vapor condenses and forms oceans and seas; the carbon dioxide and portion of the water disappear through weathering action, and are transformed into calcium carbonates by crustaceans. The water at the same time will carry down sand and clay to the oceans, which deposit thick layers of sedimentary rocks. Volcanic action gradually ceases. The supply of carbon dioxide is decreased, as is also that of water. The surface of the planet changes into a desert, in which condition Mars is at the present time. The oxygen combines in part with the nitrogen to form nitrates; in part combines with iron and is thus gradually used up like the nitrogen. The tides cease to change on account of lack of water. The atmosphere becomes thinner, the differences in temperature between day and night, summer and winter, are greater. The last gases finally disappear through their molecular motion. The Moon is in this condition at the present time, probably also Mars and the inferior planets, as also most of the moons of the other planets. The planet is then dead and unchangeable. Some day, perhaps after millions of years, the Earth will share the fate of Mars. After the extinction of the Earth, Venus will take the proud place as the leader among the planets of the solar system. What we may expect from the other still undeveloped planets it is hard to tell. Their great distance from the sun, the giver of light and heat, leads us to suppose that higher forms of life will never exist there. We can say at any rate that our Earth has been in very favorable conditions for many hundred millions of years past, and that it will probably hold this position for the same length of time to come.

A New Radium Perpetual Motion Machine.

Several attempts have been made in recent years to show the continuous nature of the energy flux from radium, among which that of Strutt in 1903 was the most successful. His instrument consisted of a fine foil electroscope, which was gradually charged by the radium rays, and which then discharged this energy on a contact, whereupon the cycle began again. A serious drawback to the efficient working of this device was the troublesome atmospheric ionization, and the necessity of placing the apparatus in a vacuum, which, of course, made the entire instrument very complicated and difficult to handle. Herr Greinacher has now constructed a new type of radium perpetual motion machine which can work in the open air, is set up and operated without difficulty, and whose movements can be demonstrated before a large audience even when using a very weak radium compound.

The accompanying figure shows a cross section of the apparatus in question. It consists in the main of two parts, namely, a brass plate *P*, entirely imbedded in paraffine, and serving to intercept the β-rays of the radium, and of an electrometer *B*, whose needle *N* is in metallic connection with the plate *P*. The layer of paraffine over *P* is about one-half millimeter (0.02 inch) thick. Over it lies a piece of aluminium foil, 0.015 millimeter (0.0006 inch) thick, which is held in position by the headscrew *K*. If a radium compound is placed upon this foil, the β-rays of the same strike the brass plate *P* without losing any of their strength. The plate *P* in its turn absorbs nearly all of the β-rays and is charged with negative elec-

tricity. As the plate is not enveloped by ionized air, it retains its charge, and this is now sent over a wire *D*, which is also imbedded in paraffine, to the electrometer. In this apparatus the tube *R*, filled with paraffine, is set directly over the electrometer. Suspended from the thin platinum (Wollastonite) wire *W* is a very light vertical, silver wire, and a rigid wire *N* soldered at right angles to this, hanging in a horizontal direction. If this combination is charged, the needle *N* is attracted to the electrometer tubes *B* and drawn into these. The rotation of the wire can be watched by observing the instrument, or else a light spot "indicator" can be thrown on a large screen for the benefit of an audience by using a mirror *S*. In one of the tubes *B* is a very fine platinum wire *C*, and a similar platinum stirrup is soldered to the needle *N* facing wire *C*. When the needle has rotated in through a certain angle, the two platinum wires come in contact, the rotating system discharges its electricity and returns to the rest position. Gradually, however, the charge conducted through P increases in magnitude, the needle turns again toward the contacts, until there is another discharge, and thus the play goes on indefinitely. The electric voltage of the needle when rotating is considerable, amounting to 10 volts and more. The air in the brass box *G* should not be ionized too strongly by the radium, as otherwise the system will not reach this high voltage. It has been found by experience that the best results are achieved by making the tube *R* of sufficient length. The distance between the radium and the box is about three feet, and the cover of box *G* is five millimeters (0.2 inch) thick. The needle rotates the faster, the smaller the moment of inertia of the system, and the greater the rate of charging the needle. The length of the platinum wire has also some influence on the action of the machine, and a five-sixth centimeter (0.33 inch) wire will give prompt action and yet a sufficiently slow rotation of the needle. Using paraffin for insulation, and a very thin copper wire *D* increases the speed of charging and keeps the ionization process in box *G* at its lowest figure. The instrument is set up for operation in the following way: The tube *R* is drawn out of its sheath, and the platinum-wollastonite wire *W*, with its hook is hung from the platinum hook *H*, which protrudes through the paraffine. Then the tube *R* is again pushed back into its sheath so that the lower hook of wire *W* reaches down into case *G*. Meanwhile needle *N* has been placed in the tubes of the electrometer, and then the two lower hooks are placed in position. Now the tubes are adjusted till the needle *N* is freely suspended, centering and leveling the suspended system by means of the thumbscrews at the base of the stand. Two glass plates on the sides of the box allow observation of the rotation of the needle. The radium compound is either spread over an area equivalent to that of plate *P*, or else is presented to the instrument in ebonite capsules or glass tubes. The latter two methods have given satisfactory results, for as small a quantity as 3 milligrams $RaBr_2$ (Radium bromide) in a glass tube kept the needle rotating for a period of 5 to 9 minutes at one charge. The needle rotates slowly at first, then faster, and then decreases again in speed owing to the influence of the air on electric losses with increasing voltage. The needle then returns to its original position, taking about one to two minutes to approach the rest position, which it never quite reaches, however, as meanwhile the second charging process has started. The effect of charges is increased considerably by the negative charges collecting in the paraffine owing to the electrons absorbed by the same. Numerous tests have proved the time for one period of action to range between 5 minutes 8 seconds to 8 minutes 56 seconds, with an average of 8 minutes 34 seconds. These constants are remarkable as the instruments were not protected against shocks. Moreover, the influence of other radioactive compounds, which causes electric leakage and losses and lowers the speed of charging, was not eliminated. Of course, it is advisable to keep such materials away and to avoid especially the penetration of radium emanations into the box *G*.

It might be mentioned that a German firm in Zürich has undertaken to manufacture this apparatus in quantities for practical demonstration purposes, so that the instrument may be said to have passed the experimental stage and to have entered into a field of useful action.—*Berichte der Deutschen, Physikalischen Gesellschaft.*

To Cast Clay in Plaster Molds, According to Ch. Lauth.—Inasmuch as the absorption of the water by the plaster from the clay milk in contact with it, produces a stiff but not sufficiently strong layer of clay, the solidity of the clay layer must be supported by air pressure. Either the mold must be enclosed in an air-tight metallic case and the air exhausted, or artificially produced air pressure must be resorted to.

Science Notes.

The Motion of the Sun Through Space.—Prof. Boss has been carrying on researches to re-determine the translational velocity of the sun through space. His results are published in the *Astronomical Journal* and the figure which he arrives at is 14.9 miles per second. He regards the value formerly obtained by spectroscopic methods, namely, 12.4 miles per second, as subject to systematic error.

The Height of Waves.—Mr. Vaughan Cornish has once more attacked the much-discussed question of the height of waves. He thinks that in the North Atlantic Ocean they do not ordinarily exceed some 43 feet, though through interference effects they may rise to as much as 59 feet. As for the length between crests, it is estimated in the Atlantic at some 390 to 400 feet, although some observers assert that they have measured distances of as much as 650 feet from crest to crest. As a matter of fact, the biggest waves are not to be found in the Atlantic, but in the ocean south of Cape Horn and south of the Cape of Good Hope. It is generally admitted that in this region waves are sometimes encountered that measure over 1,100 feet from crest to crest.—*Cosmos.*

The Fusion of Carbon.—When carbon is heated very highly under ordinary conditions, it volatilizes without fusion. The Italian physicist, La Rosa, however, reports that he has observed a condition of incipient fusion in the singing arc, which gives a higher temperature than the ordinary electric arc. Sugar charcoal formed of one of the electrodes exhibited a sort of drop formation which clearly indicated incipient fusion. Recently La Rosa has repeated his experiments with a new method of heating. He now relies simply on the regular Joule effect, that is to say, the heating of a conductor carrying a current, by virtue of its ohmic resistance. The carbon filament to be fused was firmly united to two carbon rods serving as leads for the current. This latter, at its maximum, had an intensity of 90 amperes and a tension of 150 volts. If this current strength is applied suddenly, the filament bursts with explosive violence, but if the current is gradually brought up to its maximum, the filament is presently seen to bend down under the influence of its own weight. After the filament has undergone this treatment it shows unmistakable signs of the temperatures to which it has been submitted. The surface displays the appearance of being covered with little round droplets. The complete fusion of carbon has not been realized, but we have reason to hope that it may be accomplished by the aid of intense pressures.—*Cosmos.*

The Bacteriology of the Mouth.—Mr. E. C. Bousfield, writing in the *Lancet*, gives some interesting and rather startling figures which are well worth quoting. He states that he has found the mouth, on waking in the morning, to contain about three thousand million bacteria capable of being removed by a five-fold rinsing with 25 cubic centimeters of water each time. After ordinary washing of the teeth with a hard tooth brush, about one-fourth the number could still be rinsed away. After using euthymol tooth paste only one hundred and twenty millions were left.

Non-hygrometric Table Salt.—The choking up of the perforations in the cap of salt cellars is a most irritating effect which is only too common, especially in damp weather. It is perhaps not very generally known that it is quite possible to prepare salt in such manner that it will not take up moisture from the air and cake. The following directions for preparing a non-hygrometric salt are given in the *Journal de la Santé*: In order to obtain pure sodium chloride dissolve ordinary salt in three times its weight in water, add sodium carbonate drop by drop until all the alkali salts are precipitated; filter and evaporate in a porcelain dish, fish out with a spatula the crystals forming during evaporation and allow them to drain in a funnel. Wash the crystals with a small amount of distilled water, dry and powder.

Causes of Variation in the Polarization of Skylight—In a paper read before the Philosophical Society of Washington, H. H. Kimball shows that while the polarization of sky light is greatly modified by reflection from the surface of the earth, it is intimately connected with meteorological processes and conditions. Decreased polarization may be produced by mechanical haze, due to the presence of large particles of any description in the atmosphere, or by optical haze, due to a lack of homogeneity in the atmospheric layers.

Water Color Painting on Parchment.—In order to paint upon parchment with water colors it is necessary so to treat the material that it does not wrinkle when wetted with the colors, which must be largely diluted. Generally, it is sufficient for this purpose to rub very fine Spanish white upon the surface of the parchment. If, however, the parchment has been handled much before it is used, it is advisable to add a little beef-gall to the colors used. This causes them to spread very much better. In any case, the parchment must be laid out flat to dry, and the drying should be allowed to proceed very slowly and without exposure to a source of heat.—*Cosmos.*

Electrical Notes

A Wireless Ship's Compass.—The number of applications of the latest developments along this line is the use of electric waves for the purpose of indicating their bearings to vessels befogged at sea. The wireless compass is an invention of the Italian officers Bellini and Tosi, and a series of tests of its practical utility is to be made shortly near the French coast. From a number of points on the coast special signals are to be sent out by means of electric waves. This will enable the ships equipped with Bellini-Tosi compasses to determine the directions from which the signals proceed. The signal from each coast station is tuned to a separate frequency, and since in addition to this the signals correspond to different letters of the alphabet, the chances of one station being mistaken for another are practically nil. The compass is an instrument which, once its frequency is tuned for a given pitch, will indicate automatically, by means of a pointer, in what direction the signaling station lies, so that the observer can determine precisely the exact direction and position of the several stations, in spite of the thickest fog, and can thus find the bearings of the ship with absolute certainty.—*Elektrophysikalische Rundschau.*

Wireless Telegraphy Within the Earth's Crust.—There is a general impression that radio-telegraphy is impossible between two points situated within the earth, as, for instance, two mine galleries. Contrary to this, a note by G. Leimbach in the *Annales des postes* informs us that communication is quite practicable in very dry soils of low activity. Thus, in the salt mines of Silesia the author has succeeded in establishing communication between horizontal galleries in two mines situated at a distance of about 1.2 miles from one another.

Insulators of Unusual Strength.—An insulating substance of great toughness is being introduced in England, and the claims made for it should appeal to telegraph and telephone companies. The material is weather-proof and almost indestructible, and the screw threads are accurately cut, so that they are easily fitted to the supports, without the use of cement. The insulation resistance of the insulators, as tested in water at Faraday House, was over half a million megohms. After seven days' immersion in brine the insulation resistance was about 100,000 megohms, and on applying an alternating pressure at fifty cycles per second the insulation was not broken down until pressures exceeding 13,000 volts were attained.—*Electrical Review and Western Electrician.*

Electrics Versus Horses.—According to the *Elec-Tricks*, a little monthly published by the General Vehicle Company, electric trucks saved something more than $10,000 a year for the White Express Company of New York and did better and more reliable service. The figures, which appear to have been carefully compiled, are worth studying. The magazine states that the five 3.5-ton trucks purchased by the company replaced twenty-five horses, the maintenance of which cost $105 a day (including rent, feed, bedding, shoeing, stableman, veterinary, etc.); also ten wagons, with five men and five helpers at $21 a week, for one driver and one helper. On long routes, such as Coney Island, the two-ton truck replaces one wagon and four horses used in alternate daily relays.

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